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THE
WORKS
OF THE HONOURABLE
ROBERT BOYLE.

In SIX VOLUMES.

To which is prefixed
The LIFE of the AUTHOR.

VOLUME THE SECOND.

A NEW EDITION.



H. Gravelot inv. et delin.

L O N D O N :

Printed for W. JOHNSTON, S. CROWDER, T. PAYNE, G. KEARSLEY, J. ROBSON,
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W. WOODFALL, J. JOHNSON, and T. EVANS.

M DCC LXXII.

SOME
CONSIDERATIONS
TOUCHING THE
Usefulness of Experimental Natural PHILOSOPHY.

Proposed in a familiar DISCOURSE to a FRIEND,

By way of Invitation to the Study of it.

The Publisher to the Reader.

IT is, courteous reader, part of the satire of *Petronius* against the vice of his own time; *Priscis temporibus, cum adhuc nuda Virtus placeret, vigeant artes ingenue, summumque certamen inter homines erat, ne quid profuturum sæculis diu lateret. Democritus omnium herbarum succos expressit, & ne lapidum virgultorumque vis lateret, ætatem inter experimenta consumpsit.* Other examples of the like industry he brings, and then concludes against the laziness and luxury of his own age: *At nos, faith he, ne paratas quidem artes audemus cognoscere, sed accusatores antiquitatis vitia tantum docemus & discimus.* It was for want of a *Democritus* or two, that he casts this hard censure upon his own time. For notwithstanding all his harangue in commendation of some ages, which were antient to his own, it is evident out of history, that there was never at once any great number, who seriously and in earnest for the benefit of mankind applied themselves to these severe scrutinies of natural bodies. It is true, that now and then, in all centuries from the beginning of the world, there have appeared some persons of a nature more refined, as if indeed (according to that fancy of the old poets) some *Prometheus* had made them either of another metal, or of another temper, from the vulgar, utterly above all mixture with, or embasement by the common fashions of this world; who did make it the end of their lives, by severing and mixing, making and marring, and multiplying variety of experiments on all bodies, to discover their hidden virtues, and so to enlarge the power and empire of man. But these were ever very few and singular. Even in that so much celebrated time of *Democritus*, these studies were so rare, that his usual exercise of the anatomy of beasts was looked upon as that, which made the soundness of his mind questionable, even as a spice of madness in him: and probably much more might the vulgar of his age have been amused, had they seen him torturing minerals and metals in the more toilsome anatomy of fire.

Now if it be a dishonourable crimination to an age, that it hath brought out no persons who make it their great endeavour *Ne quid profuturum sæculis lateat*; and if the discovery of one or two persons of this kind be enough to expiate for, and take off the dishonour of the proletarian laziness and luxury of the rest; I think I may justly esteem, that the exhibiting to the world the history of the studies of the honourable author of this piece, may serve to be the apology and defence of our age, against such censures, as that, wherewith the newly cited satirist stained his own time.

The Publisher to the Reader.

AND this was one great reason, that hath made me very forward to promote the publication of this, and divers other writings of the same noble author. For were there only tokens of endeavour in them, the proof of this endeavour (even without attainment) ought to wipe off all imputations of this nature. But this motive, (though I do account, that by exhibiting this expiation I do somewhat oblige the age, whose honour is thereby defended, yet) was far from being the most great and forcible. For the excellence of the works themselves, even as soon as they fell from the pen of the author, did long since in all equity set an Imprimatur on them:

Nec sumunt aut ponunt secures

Arbitrio popularis auras.

Epicurus, when he was casting up the account of his life, upon the very day of his death, mentions a very great pleasure, that he even then took in two parts of his former studies; and these were his *Rationes*, and his *Inventa*; points well argued, and things happily found out. The two very same particulars are principally conspicuous in this ensuing piece. There are good conclusions against the enemies of the being and providence of God in the first part, and in the second there be notices of divers *Inventa* profitable to the use of man. By the one, sound notions are proposed to the reader's apprehension from the contemplation of God's creation and government of the world, and thereby good matter is suggested to his affections for the advancement of his devotion: by the other, there are divers things delivered, which may tend to enlarge man's power of doing good: by them, in the whole, both our honour to God, and our charity to our neighbours may be assisted; in which two, the substantial part of all the most noble, not only human, but Christian virtues, both speculative and practical, are certainly contained.

I MUST not omit, that an argument of this nature, at this time, may justly be commended for its seasonableness, when divers persons, who know not the way of experimental philosophy, and are loth now to give themselves the trouble of learning it, have been making some attempts, very unthankfully, to traduce both it and its promoters.

THESE considerations passed with me for reasons, and had upon me this force and prevalence, that as soon as I had the author's leave, I durst not forbear the committing of them to the press, notwithstanding his many arguments, which were plausible enough to the contrary; as, namely, that much of the first part was written, when he was of so immature years, that should I be particular concerning his age then, to any person, who hath read the piece, the paucity of such instances might justly make me despair of begetting credit to my relation. Another objection was, that though his method did of necessity lead him to it, yet it might be looked upon as unbecoming for him to meddle with the physician's art, of which he never did (nor could, by reason of his native honour) make any profession. But these oppositions being raised upon points of curiosity in ceremony and outward decorum, were of little weight, when the fore-mentioned noble offices of charity and doing good were in the other scale.

THE greater question was; Suppose them to be published, but why now? why so soon? should not rather the edition have been delayed, until it might have come out together with the second section of the second part? (which discovers the use, that may be made of experimental learning, to advance the empire of man over other creatures) or until the common preface, and some other little tracts, all written long since, and intended to accompany this, might be revised by the author; or at least until the author might have had leisure to have made some more new and full animadversions to the receipts and processes contained in the appendix? The consideration, which answered this objection, was, that this piece, as now printed alone, would make (as you see it doth)

cloth) a very competent book, which would have by itself the perfection, if not of the whole, yet of a more principal part; and of that part, which to professors or candidates of learning is most desirable. And then the author's avocations and other studies being so many, that we could prefix no certain time for the complement of the mentioned remaining parts, I was loth to hazard the preservation of these, by deferring the impression; since I know there is no security of the continuance of those writings, which are reposed only in single, or at most in few written copies. I remember, the author had once lost for a good while one of these very essays, which are now here printed, and put beyond that danger for the future. Besides other casual accidents, the very contingency of human life, and the chance of a man's papers after death, (for to them the question of king Solomon is most proper and pertinent, *Who knows, whether then they may happen to fall into the hands of a wise man or a fool?*) were of force enough to persuade me to secure these, when it was in my power, unto the common use. Would not printing, in all probability, have preserved unto us that universal history of vegetables from the cedar of *Lebanus*, unto the moss, that groweth upon the wall, written by that wise and learned king, and the loss of which we now in vain lament? Would not printing have saved that excellent book of *Democritus*, which he inscribed his ΧΕΙΡΟΚΜΗΤΑ, or experiments of his own personal trial; so utterly lost, that the name of the piece is not mentioned among the catalogue of his writings in *Laertius*? And may not the printing of this piece be a means of the preservation (besides the notional part) of divers very useful ΧΕΙΡΟΚΜΗΤΑ of the honourable author? who hath been ever unwearied in the trial of all probable experiments, that may increase the light, or advance the profit of mankind, and whom I may now name to be that most learned and noble person Mr. *Boyle*: for the ceasing of certain considerations, that before made him willing to have his name suppressed, and the general very good acceptance of this discourse, have extorted from his honour, that he no longer conceal himself to be the author.

BUT before I leave the reader, I must give him this single advertisement, that the passages included within the paratheses or crochets, as the press styles them, that is, between any two such marks as these [] were inserted long since the writing of these essays, upon the relection of some parts of the book before he sent it to me: which I therefore did so distinguish, and do intimate, that there may appear no inconsistency in our author, and the reader may not marvel to find some things very recent in a book written several years ago. Farewell.

RO. SHARROCK.

The Author's Advertisement about the following Essays.

THAT the title of the following treatise might not raise in the reader an expectation of more than he will find in the book, I think myself obliged to inform him, that, though it come not forth before, divers parts were sent to the press in 1660, or 1661, and this present year 1663; yet the very last essay of it was written divers years before: since when those papers were left, sometimes in the hands of friends, and sometimes in distant places, where I could not come at them: which I mention, that the reader may neither wonder nor blame me, if he now meet with some things in them, that have already been published by others, or are more vulgarly known, than my way of mentioning them implies. For it may, this notwithstanding, very well be, that when I writ them, no body had yet lighted on some of them, and that others of them did then but begin to be taken notice of. And as for the five first

essays, which treat of the usefulness of natural philosophy to the mind of man, though by my addressing them all the way to the gentleman I call *Pyrophilus*, they may seem to have been originally written to the same person, and about the same time with the essays, that make up the second part; yet indeed a great portion of the first part was written, as I remember, 10 or 12 years ago, (when I was scarce above 21 or 22 years old) to another friend, to whom the considerations, that served to confirm piety, and excite devotion, were far more acceptable than those, that were more purely physiological. So that having, whether through laziness, or want of leisure, contented myself to substitute the name of *Pyrophilus* for that of my other friend (who was not unwilling I should do so) in a discourse written, when I was so young, I would not have the reader think, that I do now so approve of all those youthful discourses (which I therefore suffer to pass abroad without a name) as to think all the tenets they proposed to be irrefragable truths, or all the reasonings they contain, to be demonstrative; and that I would at present have my judgment estimated according to their cogency. But yet I do, without much reluctance, comply with those friends, who would by no means consent, that the five first essays of this treatise should not come forth with the rest; partly because not writing all things for all readers, I hold it not unfit to publish something to gratify those, who desire with me, to be both excited and assisted to admire and praise the great and wise Author of all things; partly because the treatise would seem maimed and incomplete, if the latter essays should come abroad without the rest; and partly too, because learned men have been pleased to assure me, that those essays are not destitute of notions and ratiocinations, that are not altogether vulgar or contemptible. However those readers, that either cannot relish, or at least desire not any thing, but what is merely physiological, may, thus advertised, pass by the former part of this treatise, and content themselves to read over the latter; though they, who shall take the pains to read both, will not, perhaps, think their labour lost; since I have taken care to leave even the former part as little disfigured with experiments and useful notions, as, the argument considered, I conveniently could. And since also, for the paucity of such things in the first part, I have endeavoured to make amends in the second, which is almost wholly physiological; concerning which, nevertheless, I shall admonish the reader: and indeed the whole tenets, that make up the following book, are by no means to be looked upon as published for an accurate treatise of the usefulness of true physiology, but as familiar writings, that want only the formality of *salvo* and *vale* to pass for physiological and medical epistles; consisting of such loose observations, as I thought might be this way preserved, and did not so properly belong to my other writings, as they seemed fitted for the use, and whereto I have applied them; namely, that being drawn up together into one treatise, their union might enable them to make the greater impression, and might (somewhat at least) recommend that sort of learning to a beginner. And one thing, that must be especially comprehended in this admonition, is, that the particulars I have mentioned, to shew of what use chymical experiments may be to a physician, are not, possibly, the chiefest, that even I could set down, if I were not restrained by some justifiable considerations; especially till I see what entertainment the things I now adventure abroad, will meet with there: some of those, I reserve, appearing such to me, that I confess, I do not slight them enough to be fond of obtruding them upon the publick, if I thought they would not be welcome to it. And I do so little desire to have, what I have written, looked upon as the most that can be said, to shew the usefulness of experimental philosophy, that I scruple not to acknowledge, there are things, which incline me to suspect, that some in the world, though not particularly known to me, may have arcana, to which most of the processes I reserve, as well as all, that is commonly known in chymistry, may prove little more than trifles.

OF THE
USEFULNESS
OF
NATURAL PHILOSOPHY.

PART I.

Of its Usefulness in reference to the Mind of Man.

ESSAY I.

*Of the Usefulness of EXPERIMENTAL PHILOSOPHY, principally
as it relates to the Mind of Man.*

THE natural philosophy, wont to be taught in schools, being little other than a system of the opinions of *Aristotle*, and some few other writers, is not, I confess, *Pyrophilus*, very difficult to be learned; as being attainable by the perusal of a few of the more current authors. But, *Pyrophilus*, that experimental philosophy, which you will find treated of in the following Essays, is a study, if duly prosecuted, so difficult, so chargeable, and so toilsome, that I think it requisite, before I propose any particular subjects to your inquiries, to possess you with a just value of true and solid physiology; and to convince you, that by endeavouring to addict you to it, I invite you not to mispend your time or trouble on a science unable to merit and requite it. In order, *Pyrophilus*, to the giving you this satisfaction, give me leave to mind you, that it was a saying of *Pythagoras*, worthy so celebrated a philosopher, that there are two things, which most ennoble man, and make him resemble the gods; *to know the truth*, and *to do good*. For, *Pyrophilus*, that diviner part of man, the soul, which alone is capable of wearing the glorious image of its author, being endowed with two chief faculties, the understanding and the will; the former is blest and perfectionated by knowledge, and the latter's loveliest and most improving property is goodness. A due reflection upon this excellent sentence of him, to whom philosophers owe that modest name, should, methinks, *Pyrophilus*, very much endear to us the study of natural philosophy. For there is no human science, that does more gratify and enrich the understanding with variety of choice and acceptable truths; nor scarce any, that does more enable a willing mind to exercise a goodness beneficial to others.

The reason why the author endeavours to possess *Pyrophilus* with the true value of experimental philosophy.

To manifest these truths more distinctly, *Pyrophilus*, and yet without exceeding that brevity, my avocations and the bounds of an Essay exact of me, I shall, among the numerous advantages accruing to men from the study of the book of nature, content myself to instance only in a couple, that relate more properly to the *improving of men's understandings*, and to mention a few of those many, by which it *increases their power*.

That experimental philosophy is conducive to the improving of man's understanding and to the increasing man's power.

THE

THE two chief advantages, which a real acquaintance with nature brings to our minds, are, first, by instructing our understandings, and gratifying our curiosities; and next, by exciting and cherishing our devotion.

Arguments
to prove,
that man's
curiosity for
knowledge
is much
thereby
gratified.

AND for the first of these: Since, as *Aristotle* teacheth, and was taught himself by common experience, *all men are naturally desirous to know*; that propensity cannot but be powerfully engaged to the works of nature, which being incessantly present to our senses, do continually solicit our curiosities: of whose potent inclining us to the contemplation of nature's wonders, it is not, perhaps, the inconsiderablest instance, that, though the natural philosophy hitherto taught in most schools hath been so litigious in its theory, and so barren as to its productions; yet it hath found numbers of zealous and learned cultivators, whom sure nothing but men's in-bred fondness for the object it converses with, and the end it pretends to, could so passionately devote to it.

AND since that (as the same *Aristotle*, taught by his master *Plato*, well observes) admiration is the parent of philosophy, by engaging us to enquire into the causes of the things at which we marvel; we cannot but be powerfully invited to the contemplation of nature, by living and conversing among wonders, some of which are obvious and conspicuous enough to amaze even ordinary beholders; and others admirable and abstruse enough to astonish the most inquisitive spectators.

A relation
of the
transport
and sur-
prizal of a
maid born
blind, when
being about
18 years
old, she ob-
tained the
first sight of
the various
objects
the world
instantly
presented
her with.

THE bare prospect of this magnificent fabrick of the universe, furnished and adorned with such strange variety of curious and useful creatures, would suffice to transport us both with wonder and joy, if their commonness did not hinder their operations. Of which truth, Mr. *Stepkins*, the famous oculist, did not long since supply us with a memorable instance: For (as both himself and an illustrious person that was present at the cure, informed me) a maid of about eighteen years of age, having by a couple of cataracts, that she brought with her into the world, lived absolutely blind from the moment of her birth; being brought to the free use of her eyes, was so ravished at the surprizing spectacle of so many and various objects, as presented themselves to her unacquainted sight, that almost every thing she saw, transported her with such admiration and delight, that she was in danger to lose the eyes of her mind by those of her body, and expound that mystical Arabian proverb, which advises, *to shut the windows, that the house may be light*.

That the
knowledge
of the in-
ward archi-
tecture, and
contrivance
of nature
is more de-
lightful than
the sight of
outward
shapes.

BUT if the bare beholding of this admirable structure, is capable of pleasing men so highly; how much satisfaction, *Pyrophilus*, may it be supposed to afford to an intelligent spectator, who is able both to understand and to relish the admirable architecture and skilful contrivance of it: for the book of nature is to an ordinary gazer, and a naturalist, like a rare book of hieroglyphicks to a child, and a philosopher; the one is sufficiently pleased with the oddness and variety of the curious pictures that adorn it; whereas the other, is not only delighted with those outward objects, that gratify his sense, but receives a much higher satisfaction, in admiring the knowledge of the author, and in finding out and enriching himself with those abstruse and veiled truths dexterously hinted in them.

Examples
and instan-
ces of the
prevalence
of the plea-
sure, that
arises from
the attain-
ment of
knowledge.

YES, *Pyrophilus*, as the understanding is the highest faculty in man, so its pleasures are the highest he can naturally receive. And therefore I cannot much wonder, that the famous *Archimedes* lighting in a bath upon an expedient to resolve a perplexing difficulty in natural philosophy, should leap out of the bath, and run unclothed like a madman, crying nothing but *Εὕρηκα, Εὕρηκα, I have found it, I have found it*. Nor do I so much admire, as deplore the fatally venturous curiosity of the elder *Pliny*, who, as the younger relates, could not be deterred by the formidableness of destructive flames vomited by *Vesuvius*, from endeavouring by their light to read the nature of such Vulcanian hills; but in spite of all the dissuasions of his friends, and the affrighting

affrighting eruptions of that hideous place, he resolved, that flaming wonder should rather kill him, than escape him; and thereupon approached so near, that he lost his life to satisfy his curiosity, and fell (if I may so speak) a martyr to phyfiology. For we daily see alchymists hazard their lives on mineral experiments in furnaces, where, though the fires are not so vast and fierce, as those that *Pliny* went to confider, yet the (dangerous, when not pernicious) fumes, do sometimes prove as fatal.

ONE would think, *Pyrophilus*, that the converfing with dead and stinking carcafles (that are not only hideous objects in themselves, but made more ghastly by putting us in mind, that ourselves must be fuch) should be not only a very melancholy, but a very hated employment. And yet, *Pyrophilus*, there are anatomists, who dote upon it; and I confess its instructiveness hath not only so reconciled me to it, but so enamoured me of it, that I have often spent hours much less delightfully, not only in courts, but even in libraries, than in tracing in those forsaken mansions, the inimitable workmanship of the omniscient Architect.

THE curious works of famous artificers are wont to invite the visits, and excite the wonder of the generality of inquisitive persons. And I remember, that in my travels, I have often taken no small pains to obtain the pleasure of gazing upon some masterpiece of art: but now, I confess, I could with more delight look upon a skilful dissection, than the famous clock at *Straßburgh*. And, methinks, *Aristotle* discourses very philosophically in that place, where passing from the consideration of the sublimest productions of nature, to justify his diligence in recording the more homely circumstances of the history of animals, he thus discourses: *Restat* (saith he) *ut de animanti natura differamus, nihil pro viribus omittentes vel vilius vel nobilius. Nam & in iis, quæ hoc in genere minus grata nostro occurrunt sensui, natura parens & autor omnium miras excitat voluptates hominibus, qui intelligunt causas & ingenue philosophantur. Absurdum enim nulla ratione probandum est, si imagines quidem rerum naturalium non sine delectatione propterea inspicimus, quod ingenium contemplamur, quod illas condiderit, id est, artem pingendi aut fingendi; rerum autem ipsarum naturæ ingenio miraque solertia constitutam contemplationem non magis prosequamur atque exosculemur, modo causas perspicere valeamus:* ‘It remains (saith he) that we discourse of the natures of animals, being circumspect to omit none either of the nobler or inferiour sort: for even from those creatures, which less please our sense, does the universal parent, nature, afford incredible contentments to such persons, as understand their causes, and philosophize ingenuously. Since it were absurd and inconsistent to reason, if we should behold the portraitures of natural things with delectation, because we observe the accurateness, wherewith they are designed, namely, the skill of painture or sculpture, and not much more affect and pursue the contemplation of things themselves, contrived by the exquisite artifice and sagacity of nature, provided we be able to understand their causes.’ And the better to make out to you, *Pyrophilus*, the delightfulness of the study of natural philosophy, let me observe to you, that those pleasing truths it teacheth us, do highly gratify our intellectual faculties, without displeasing any of them: for they are none of those criminal pleasures, which injured and incensed conscience does very much allay, even in the fruition, and turns into torments after it. Nor are the enquiries I am recommending of that trifling and unserviceable sort of employments, which though conscience condemns not as unlawful for a Christian, reason disapproves as not worthy of a philosopher; and wherewith to be much delighted, argues a weakness; as to be pleased with babes and whistles supposes unripe and weak intellectuals: but the contemplation of nature is an employment, which both the possessors of the sublimest reason, and those of the severest virtue, have not only allowed, but cultivated. The learned author of the book *De Mundo*, ascribed to *Aristotle*,

That the knowledge of the most curious artificial works is not more delightful than the knowledge of natural.

Aristot. de Part. Anim. lib. I. c. 5.

That this delight herein is altogether inoffensive.

Instances
of the
esteem di-
vers antient
philosophers
had for it.

begins it with this eulogium of natural philosophy: *Mibi quidem sæpe* (says he) *divina quædam res, Alexander, admirationeque digna visa est philosophia; præcipuè verò in ea parte, in qua sola ipsa sublimè sese tollens, ad contemplandas rerum naturas magno illic studio contendit existentem in eis veritatem pernoscere.* ‘Philosophy (says he) O Alexander, hath oftentimes seemed to me a divine and admirable thing; but chiefly, that part of it, which aspires to contemplate the natures of things, imploying its utmost power in searching out the truth contained in them.’ The reasonableness of which commendation he handsomely enough prosecutes in the subsequent discourse; to which I shall refer you, that I may proceed to mind you, that *Pythagoras, Democritus, Plato*, and divers others of those, whose wisdom made after-ages reverence antiquity, did not only esteem the truths of nature worth studying for, but thought them too worth travelling for as far as those eastern regions, whose wise-men were then cried up for the best expositors of the obscure book of nature. And that severe teacher, and persuasive recommender of the strictest virtue, *Seneca*, (whose eminent wisdom made him invited to govern him, that was to govern the world, and who so often and so excellently presses the husbanding of our time) does not only in several passages of his writings praise a contemplation of nature, but writes himself seven books of natural questions, and addresses them to that very *Lucilius*, whom in his epistle he takes such pains to make compleatly virtuous; and in his preface, after he had said according to his manner, loftily, *Equidem tunc naturæ rerum gratias ago, cum illam non ab hac parte video, quæ publica est, sed cum secretiora ejus intravi, cum disco, quæ universi materia sit, quis author, aut custos, &c.* ‘Then do I pay my acknowledgments to nature, when I behold her not on the outside, which is obvious to publick view, but am entered in- to her more secret recesses; when I understand what the matter of the universe is, who its author, and preserver, &c.’ He concludes in the same strain, *Nisi ad hæc admitterer, non fuerat operæ pretium nasci*: ‘Had I been debarred from these things, it would not have been worth coming into the world.’ And to add what he excellently says in another treatise, *Ad hæc querenda natus* (says he, having spoken of enquiries concerning the universe) *estima quàm non multum acceperit temporis, etiamsi illud totum sibi vindicet, cui licet nihil facilitate eripi, nihil negligentia patiatur excidere; licet boras suas avarissimè servet, & usque in ultimæ ætatis humanæ terminos procedat; nec quicquid illi, ex eo quod natura constituit, fortuna concutiat, tamen homo ad immortalium cognitionem nimis mortalis est. Ergo secundum naturam vivo, si totum me illi dedi, si illius admirator cultorque sum. Natura autem utrumque facere me voluit & agere, & contemplationi vocare*: ‘Being born designedly for searching out these things, consider, that the portion of time allotted to man is not great, if this study should ingross it all; since though he should preserve his hours with the greatest frugality all his life-time, not suffering any to be stolen from him, or slide away negligently, and never be disturbed by accidents of fortune in the employment nature has appointed him, yet is he too mortal to attain the knowledge of immortal things. Wherefore, I live agreeable to nature, when I give up my self wholly to her, and am her admirer and adorer: moreover, nature hath designed me to act, and imploy my self in contemplation.’ How far religion is from disapproving the study of physiology, I shall have occasion to manifest ere long, when we shall come to shew, that it is an act of piety to offer up for the creatures the sacrifice of praise to the creator; for, as anciently among the Jews, by virtue of an Aaronical extraction, men were born with a right to priesthood; so reason is a natural dignity, and knowledge a prerogative, that can confer a priesthood without unction or imposition of hands. And as for reason, that is so far from making us judge that imployment unworthy of rational creatures, that those philosophers (as *Aristotle, Epicurus, Democritus, &c.*) that have improved reason to the greatest height, have the most seri-

ously

*Seneca in
Præf. lib. 1.
Nat. Quest.*

*Sen. de Otio
Sap. c. 32.*

How this
study con-
sists with
religion.

ously and industriously employed it to investigate the truths, and promote the study of natural philosophy.

AND indeed, that noble faculty called reason, being conscious of the great progress it may enable us to make in the knowledge of nature's mysteries, if it were industriously employed in the study of them, cannot but, like a great commander, think it self disobliged by not being considerably employed. And certainly we are wanting to our selves, and are guilty of little less than our own degradation, that being by God's peculiar vouchsafement endowed with those noble faculties of understanding, and discoursing, and placed amidst a numberless variety of objects, that incessantly invite our contemplations, can content our selves to behold so many instructive creatures, which make up this vast universe, whose noblest part we are designed to be, with no more, or but little more discerning eyes than those less favoured animals, to whom nature hath denied the prerogative of reason, as we deny our selves the use of it. *Aristotle* well observes, that among animals, man alone is of an erected stature; and adds, That it is because his nature hath something in it of divine: *Officium autem divini* (infers he) *est intelligere atque sapere*: 'The qualifications of a divine being, are understanding and wisdom.' And it cannot but misbecome the dignity of such a creature to live ignorant or unstudious of the laws and constitutions of that great commonwealth (as divers of the antients have not improperly stiled the world) whereof he is the eminentest part. And were we not lulled asleep by custom or sensuality, it could not but trouble, as well as it injures a reasonable soul, to ignore the structure and contrivance of that admirably organized body, in which she lives, and to whose intervention she owes the knowledge she hath of other creatures.

It is true indeed, that even the generality of men, without making it their design, know somewhat more of the works of nature, than creatures destitute of reason, can, by the advantage of that superiour faculty, which cannot but even unurged, and of its own accord make some, though but slight, reflections on the information of the senses: but if those impressions be only received and not improved, but rather neglected; and if we (contenting our selves with the superficial account given us of things by their obvious appearances and qualities) are beholden for that we know, to our nature, not our industry, we faultily lose both one of the noblest employments, and one of the highest satisfactions of our rational faculty. And he, that is this way wanting to himself, seems to live in this magnificent structure, called the universe, not unlike a spider in a palace; who taking notice only of those objects, that obtrude themselves upon her senses, lives ignorant of all the other rooms in the house, save that wherein she lurks; and discerning nothing either of the architecture of the stately building, or of the proportion of the parts of it in relation to each other, and to the entire structure, makes it her whole business, by intrapping of flies, to continue an useless life; or exercise herself to spin cobwebs, which, though consisting of very subtle threads, are unserviceable for any other than her own trifling uses. And that the contemplation of the world, especially the higher region of it, was designed for man's employment by nature's self, even the heathen poet (perhaps instructed by *Aristotle*) could observe, who sings,

*Pronaque cum spectent animalia cætera terram,
Os homini sublime dedit, cælumque tueri
Jussit, & erectos ad sidera tollere vultus.*

- ' Wise nature, framing brutes with downward looks,
- ' Man with a lofty aspect did endue,
- ' And bad him heaven with its bright glories view.

The absurdity of not employing human faculties on the contemplation of those objects to which they are fitted.

De Part. Anim. lib. 4. c. 10.

Illustrated by the similitude of a spider in a palace, taking notice of nothing beside her own cobweb.

The opinion that *Ovid*, *Seth*, *Abraham*, and *Solomon* had of man's fitness for the study of astronomy and other physiology. *Isaiah* xli. 8. *James* xi. 23.

I might annex, *Pyrophilus*, the story *Josephus* tells us in the beginning of his *Jewish Antiquities*, that it was the holy *Seth* and his posterity (who are in *Genesis* styled the sons of God) that were the inventors of astronomy, whose more fundamental observations (to perpetuate them to mankind, and sever them from the foretold destructions by fire and water) they engraved upon two pillars, the one of brick, the other of stone; the latter of which our historian reports to have been extant in *Syria* in his time. And it is an almost uncontrolled tradition, that the patriarch, whom God vouchsafes to style *his friend*, was the first teacher of astronomy and philosophy to the Egyptians, from whom, long afterwards, the Grecians learned them. *Berosus* himself records him to have been skilled in the science of the stars, as he is cited by *Josephus*, (*Ant. lib. i. c. 8.*) who a little after speaking of *Abraham* and the Egyptians, expressly affirms, that *Numerorum scientiam & siderum benignè illis communicavit: nam ante Abrahami ad se adventum, Egyptii rudes erant hujusmodi disciplinarum; quæ à Chaldaeis ad Egyptios profectæ, hinc ad Græcos tandem pervenerunt.*

Why Providence might deprive us of *Solomon's* physiology.

BUT, *Pyrophilus*, to put it out of question, that the sublimest reason needs not make the possessor of it think the study of physiology an employment below him, that unequalled *Solomon*, who was pronounced the wisest of men by their omniscient Author, did not only justify the study of natural philosophy, by addicting himself to it, but ennobled it by teaching it, and purposely composing of it, those matchless records of nature, from which I remember some Jewish authors relate *Aristotle* to have borrowed divers; which (if it be true) may well be supposed to be the choicest pieces, that adorned his philosophy, and which Providence perhaps deprived the world of, upon such a score, as it did the Jews of the body of *Moses*, lest men should idolize it, or, as some Rabbies are pleased to inform us, lest vicious men should venture upon all kinds of intemperance, out of confidence of finding out by the help of those excellent writings the cure of all the distempers their dissoluteness should produce.

Of the delight, that may arise from the variety of objects, which nature produces.

AND, *Pyrophilus*, yet a little further to discover to you the delightfulness of the contemplations of nature's works, give me leave to mind you of their almost unimaginable variety, as of a property, that should, methinks, not faintly recommend natural philosophy to curious and active intellectuals.

That there be above 6000 subjects of the vegetable kingdom.

Of an excellent *Jamaica* pepper newly brought over.

FOR most other sciences, at least as they are wont to be taught, are so narrow and circumscribed, that he, who has read one of the best and recentest systems of them, shall find little in the other books published on those subjects, but disguised repetitions; and a diligent scholar may in no long time learn, as much as the professors themselves can teach him. But the objects of natural philosophy being as many as the laws and works of nature, are so various and so numberless, that if a man had the age of *Methuselah* to spend, he might sooner want time than matter for his contemplations: and so pregnant is each of that vast multitude of creatures, that make up the naturalist's theme, with useful matter to employ men's study, that I dare say, that the whole life of a philosopher spent in that alone would be too short to give a full and perfect account of the natural properties and uses of any one of several minerals, plants, or animals, that I could name. It is an almost incredible variety of vegetables, that the teeming earth, impregnated by God's *producat terra*, does in several regions produce. Botanists have, a pretty while since, reckoned up near 6000 subjects of the vegetable kingdom; since when, divers other not described plants have been observed by herbarists, the chief of which will, I hope, be shortly communicated to the world, by that curious and diligent botanist, my industrious acquaintance, Dr. *How*, to whom I not long since presented a peculiar and excellent kind of pepper, whose shell tastes not unlike cinnamon, and smells so like cloves, that with the odour I have deceived many, which he confesses to be new even to him; it having been lately gathered in *Jamaica* (where it abounds) and

and presented me by the inquisitive commander of the English forces there. And yet, *Pyrophilus*, this great variety of simples could not deter either ancient or modern inquirers from writing entire treatises of some particular ones. So *Pliny* tells us, ^a that *The-mison* the physician published a volume (for so he called it) of that vulgar and despised herb called Plantain. So the same ^b author tells us, that *Amphilocus* writ a volume *De Medica Herba, & Cytisa*; and king ^c *Juba* another, of a sort of *Nymphæ* by him found on mount *Atlas*. And in our times, not to mention those many books, that have been written by physicians, of the structure of man's body, and *De Usu partium*, *Carolus Rosenbergius* writ some years since an entire book of *Roses*, which he calls his *Rhodologia: Martini Blochwitzius* since published another book of *Elder*, under the title of *Anatomia Sambuci*. Among the chymists, *Angelus Sala* published in distinct treatises, his *Vitriologia, Tartarologia, Saccharologia*. *Untzerus* also writ peculiar tracts *De Mercurio, De Sulphure, De Sale*. And *Paracelsus* himself vouchsafed distinct treatises to *Hypericon, Persicaria, Helleborus*, and some other particular plants. *Basiliius Valentinus* (one of the most knowing and candid chymical writers) published long since an excellent treatise of *Antimony* inscribed *Currus triumphalis Antimonii*; but though in his other, he hath also taught us divers other things concerning it, yet he left so much undiscovered in antimony, that *Angelus Sala* was thereby emboldened to publish his *Anatomia Antimonii*. And *Hamerus Poppius*, (if that be his true name) *Johannes Tholdius*, and the experienced *Alexander Van Suchten*, thought fit to write entire treatises of that same mineral, by which if they seem to eclipse the diligence of *Basiliius*, at least they bore witness to his judgment: for modestly inviting his readers to make further inquiries into the nature and preparations of that abstruse mineral, he gives this account of his leaving many things unmentioned, *That the shortness of life makes it impossible for one man thoroughly to learn antimony, in which every day something of new is discovered*. And I remember, that having lately given a chymist, upon his request, some directions for drawing, not an imaginary mercury of antimony, as those, which are wont to be taught by chymists, but a real fluid quicksilver; he some days since brought me about an ounce of it (which you may command when you please) as the first fruits of directions, differing enough from those, which I have hitherto met with in authors. A peculiar way likewise of separating from antimony, not such a substance as those, which are as improperly as vulgarly called antimonial sulphurs, but a really combustible body, which looks and burns so like common brimstone, that it is not easily distinguishable from it, we shall elsewhere, God willing, *Pyrophilus*, teach you. And I remember, that whereas, according to the way mentioned by *Basiliius* in his *Currus triumphalis*, and both generally transcribed by authors, and formerly practised by our selves, the tincture of the glass of antimony is very tedious to make, being to be drawn with spirit of vinegar, I once made a menstruum to draw it more expeditiously; which having not hitherto met with, in any of the authors I have read, I shall not conceal from you. Taking then an arbitrary quantity of the best French verdigrease, and distilling it orderly in a strong naked fire, I found the extorted liquor to extract (even in an ordinary digesting heat) from powdered antimonial glass, a blood-red tincture in three or four hours; and my curiosity leading me to abstract the menstruum from the tinging powder, and put it again upon pulverised glass, I found it again highly tinted in very few hours. And prosecuting the experiment, I found, that by drawing off the menstruum, and digesting spirit of wine upon the remaining calx, I could soon obtain a red tincture, or solution; from which some chymists, if I should tell them, what I have now told you, would perhaps expect no ordinary medicine. But this, I suppose, you will think less strange, than that with a liquor easily separated, by a way which I may elsewhere teach you, from an obvious vegetable, of which you may safely eat a whole pound at a time, I have drawn

Of divers single subjects that require large treatises to unfold them.
a *Plin.* lib. xxv. cap. 8.
b *Id.* lib. xviii. cap. 26.
c *Id.* lib. xxv. cap. 7.

How many treatises are already made of antimony, which yet has not been perfectly discovered.

Of a real mercury of antimony.

And a real combustible sulphur of antimony, that burns like ordinary brimstone.

A new tincture of antimonial glass, with the entire process to draw it.

a deep red tincture, even from crude antimony, and that in not many hours, and without heat.

Of *Gilbertus*, *Cabæus*, and *Kircherus*, who successively writ the experiments of the load-stone.

Of some new experiments hitherto undiscovered of that stone.

That admirable speculations may arise from the most despicable productions of nature.

AND to these experiments of antimony, I might (partly from the communication of my friends, and partly from some trials of my own) add divers other undivulged experiments relating to that mineral, if it were not now more seasonable, reserving them for other papers, to mind you, that the learned *Kircherus* hath enriched us with a great volume in folio, of light and shadows; and another in quarto, of the load-stone: and yet none of these have so exhausted the subjects they have treated of, but that an after enquirer may be able to recruit their observations with many new ones, perhaps more numerous or more considerable than the former: as after our learned countryman *Gilbertus* had written a volume of the load-stone, the Jesuit *Cabæus* was not by that deterred from writing another of the same subject: and though since *Cabæus* the ingenious *Kircherus* have so largely prosecuted it in his voluminous *Ars Magnetica*, yet he has not reaped his field so clean, but that a careful gleaner may still find ears enough to make some sheaves. And what I have lately tried or seen, makes me think it very possible to recruit those many of *Kircherus*, with some further magnetical experiments unmentioned in his book. And I have, the very day I writ this, made in that admirable stone a not inconsiderable experiment, not extant (that I remember) there: for taking an oblong load-stone, and heating it red-hot, I found the attractive faculty in not many minutes, either altogether abolished, or at least so impaired and weakened, that I was scarce, if at all able to discern it. But this hath been observed, though not so faithfully related, by more than one; wherefore I shall add, that by refrigerating this red-hot load-stone either north or south, I found that I could give its extremes a polarity (if I may so speak) which they would readily display upon an excited needle freely placed in æquilibrium: and not only so, but I could by refrigerating the same end sometime north, and sometime south, in a very short time change the poles of the load-stone at pleasure, making that which was a quarter of an hour before the north pole, become the south; and on the contrary, the formerly southern pole become the northern. And this change was wrought on the load-stone, not only by cooling it directly north and south, but by cooling it perpendicularly; that end of it which was contiguous to the ground growing the northern pole, and so (according to the laws magnetical) drawing to it the south end of the needle; and that which was remotest from it, the contrary one: as if indeed the terrestrial globe were, as some magnetick philosophers have supposed it, but a great *Magnes*, since its effluvia are able, in some cases, to impart a magnetick faculty to the loadstone it self. Some other experiments of this nature, not extant in *Kircherus*, we may have elsewhere fit opportunity to mention. And indeed, that ænigmatical mineral (if I may so call it) the load-stone, is a subject so fertile in rarities, that, I hear, he himself is reprinting that accurate treatise, with new large additions.

NOR are the smallest and most despicable productions of nature so barren, but that they are capable both to invite our speculations, and to recompense them. *Pliny* in the eleventh book of his natural history, where he treats of insects, is a little after the entrance transported with an unwonted admiration of the workmanship of nature in them: *Nusquam alibi* (says he) *spectatiore naturæ rerum artificio*: ‘In nothing elsewhere (saith he) is the workmanship of nature more remarkable than in the contexture of these little creatures.’ And after a wonder, not unworthy a philosopher, he concludes, *Rerum natura nusquam magis quam in minimis tota est*: ‘Nature in her whole power is never more wholly seen than in her smallest works.’ To which *epiphonema* he adds this sober and philosophical admonition: *Quapropter, quæso, ne hæc legentes, quoniam ex his spernunt multa, etiam relata fastidio damnent, cum in contemplatione naturæ nihil possit videri.*

videri supervacaneum: 'Wherefore I would request the perusers of these discourses, that although the subjects we treat of are contemptible in their eyes, they would not therefore disdain the relations we shall make of them; since nothing ought to seem superfluous in the contemplation of nature.' I remember, that it is from the consideration of so despicable a part as the skin of the foal of the foot, that *Galen* takes occasion to magnify the wisdom of God in those excellent terms, that we shall have occasion to mention hereafter. And, as he says rarely well, though some creatures seem made of much coarser stuff than others, yet even in the vilest, the Maker's art shines through the despicableness of the matter. For idiots admire in things the beauty of their materials; but artists, that of the workmanship: to which, after a great deal of philosophical discourse, he adds, *Neque oculo nec cerebro deterius est pes constructus, si utraque pars ad actiones, cujus gratia fuit facta, se habeat optimè; neque cerebrum sine pede se probe haberet, neque pes sine cerebro: eget enim, opinor, illud vehiculo, hic autem sensu*: 'Nor is the foot worse contrived than the brain or eye, provided each part be duly disposed for the performance of the actions to which it was designed: since the brain could not conveniently want the foot, nor the foot the brain. For, I conceive, that one stands in need of a support for local motion; and the other, of a source, from whence to derive the faculties of feeling.' To which we may annex that judicious reasoning of *Aristotle*, who, descending from the contemplation of the sublimer works of nature, to treat of the parts of animals, thus endeavours to keep his readers from thinking, that the object of it must render that enquiry despicable: *Restat* (says he) *ut de animanti natura differamus*. And having set down those words, which you have not long since read, in connection to these, he thus prosecutes his discourse: *Quamobrem, viliorum animalium disputationem perpensionemque fastidio quodam puerili sprevisse, molestèque tulisse dignum nequaquam est: cum nulla res sit naturæ, in qua non mirandum ali-quod habeatur. Et quod Heraclitum ferant dixisse ad eos, qui cum alloqui eum vellent, quod fortè in casa furnaria quadam caloris gratia sedentem vidissent, accedere temperarunt, ingredi enim eos fidenter jussit; quoniam, inquit, ne huic quidem loco dii desunt immortales; hoc idem in indaganda quoque natura animantium faciendum est. Aggredi enim quæque sine ullo pudore debemus; cum in omnibus naturæ numen, & honestum pulchrumque insit ingenium*: 'Wherefore it is altogether unseemly to reject with a kind of childish nicety, or be offended at the discourse and speculation of inferior animals; since there is nothing in all nature, but contains in it somewhat worthy of admiration. And as it is recorded of *Heracitus*, that seeing some persons desirous to speak with him, refused to approach towards him, because they beheld him warming himself in a miserable cottage, he bad them come in without scruple, since here also (saith he) are the immortal gods present: so in like manner ought we to be highly persuaded of the dignity of animals, when we make enquiries into their natures. Which we ought in no wise to be ashamed of; since the mighty power and laudable wisdom of nature is conspicuous in all things.' Nay, *Paracelsus* himself, as haughty as he was, was philosopher enough not to disdain to write a book *De Mysteriis Vermium*; wherein, though, according to his manner, he hath set down many extravagances, he is more candid in the delivery of several remedies (which experience hath recently taught us to be more effectual than probable) than in most other of his writings. And in that treatise he justly reprehends the laziness and pride of those physicians, who not only neglect and scorn enquiries of nature themselves, but when the fruits of such enquiries are presented them by others, instead of a grateful acceptance, receive them with contempt and derision. To which, a while after, he adds, what is most true, 'That God hath created nothing so vile, despicable, abject, or filthy in the world, that may not make for the health and use of man.' And certainly, whatever God himself has been pleased to

Whatever God has thought worthy of making, man should not think unworthy of knowing.

think

think worthy his making, its fellow-creature man should not think unworthy of his knowing. Nor is it a disparagement to a human notion, to represent a creature, which has the honour to have been framed according to a divine idea; and therefore the wisest of men, in his natural history, scruples not to write as well of abject reptiles, as of lions, eagles, elephants, and other noble animals; and did not only treat of the tall cedars of *Lebanon*, but that despicable plant (whatever it be that is designed by the Hebrew *ezob*) which grows out of the wall. For my part, if I durst think my actions fit to be examples, I should tell you, that I have been so far from that effeminate squeamishness, that one of the philosophical treatises, for which I have been gathering experiments, is of the nature and use of dungs. And though my condition does (God be praised) enable me to make experiments by others hands; yet I have not been so nice, as to decline dissecting dogs, wolves, fishes, and even rats and mice, with my own hands. Nor, when I am in my laboratory, do I scruple with them naked to handle lute and charcoal.

I SHOULD here, *Pyrophilus*, cease to entertain you with discourses of the pleasantness of natural philosophy, but that I remember I have not yet told you, that the study of physiology is not only delightful, as it teaches us to know nature, but also as it teaches us in many cases to master and command her. For the true naturalist (as we shall see hereafter) does not only know many things, which other men ignore, but can perform many things, which other men cannot do; being enabled by his skill not barely to understand several wonders of nature, but also partly to imitate, and partly to multiply and improve them. And how naturally we affect the exercise of this power over the creatures, may appear in the delight children take to do many things (which we may have occasion to mention elsewhere) that seem to proceed from an innate propensity to please themselves in imitating or changing the productions of nature.

AND sure it is a great honour, that the indulgent Creator vouchsafes to naturalists, that though he gives them not the power to produce one atom of matter, yet he allows them the power to introduce so many forms (which philosophers teach to be nobler than matter) and work such changes among the creatures, that if *Adam* were now alive, and should survey that great variety of man's productions, that is to be found in the shops of artificers, the laboratories of chymists, and other well furnished magazines of art, he would admire to see what a new world, as it were, or set of things has been added to the primitive creatures by the industry of his posterity.

AND though it be very true, that man is but the minister of nature, and can but duly apply agents to patients, (the rest of the work being done by the applied bodies themselves;) yet by his skill in making those applications, he is able to perform such things, as do not only give him a power to master creatures otherwise much stronger than himself, but may enable one man to do such wonders, as another man shall think he cannot sufficiently admire. As the poor Indians looked upon the Spaniards as more than men, because the knowledge they had of the properties of nitre, sulphur and charcoal duly mixed, enabled them to thunder and lighten so fatally, when they pleased. And this empire of man, as a naturalist, over the creatures may perchance be to a philosophical soul preserved by reason untainted with vulgar opinions, of a much more satisfactory kind of power or sovereignty than that, for which ambitious mortals are wont so bloodily to contend. For oftentimes this latter being commonly but the gift of nature, or present of fortune, and but too often the acquist of crimes, does no more argue any true worth or noble superiority in the possessor of it, than it argues one brass counter to be of a better metal than its fellows, in that it is chosen out to stand in the account for many thousands pounds more than any of them. Whereas the dominion, that physiology gives the prosperous studier of it (besides that it is

wont

Of the dominion and power that physiology gives the prosperous studier of it.

wont to be innocently acquired, by being the effect of his knowledge) is a power, that becomes man as man. And to an ingenious spirit, the wonders he performs bring perchance a higher satisfaction, as they are proofs of his knowledge, than as they are productions of his power, or even bring accessions to his store.

ESSAY II. *Of the same.*

THE next advantage, *Pyrophilus*, that we mentioned the knowledge of nature to bring to the minds of men, is, that therein it excites and cherishes devotion; which when I say, *Pyrophilus*, I forget not, that there are several divines (and some of them eminent ones) that out of a holy jealousy (as they think) for religion, labour to deter men from addicting themselves to serious and thorough inquiries into nature, as from a study unsafe for a Christian, and likely to end in atheism, by making it possible for men (that I may propose to you their objection as much to its advantage as I can) to give themselves such an account of all the wonders of nature, by the single knowledge of second causes, as may bring them to disbelieve the necessity of a first. And certainly, *Pyrophilus*, if this apprehension were well grounded, I should think the threatened evil so considerable, that instead of inviting you to the study of natural philosophy, I should very earnestly labour to dissuade you from it. For I, that had much rather have men not philosophers than not Christians, should be better content to see you ignore the mysteries of nature than deny the author of it. But though the zeal of their intentions keep me from harbouring any unfavourable opinion of the persons of these men, yet the prejudice that might redound from their doctrine (if generally received) both to the glory of God from the creatures, and to the empire of man over them, forbids me to leave their opinion unanswered; though I am sorry, that the necessity of vindicating the study I recommend to you from so heinous a crime as they have accused it of, will compel me to theologize in a philosophical discourse: which that I may do, with as much brevity as the weight and exigency of my subject will permit, I shall content myself only in the explication of my own thoughts, to hint to you the grounds of answering what is alledged against them.

That the knowledge of nature excites and cherishes devotion.

AND first, *Pyrophilus*, I must premise, that though it may be a presumption in man, (who to use a Scripture expression, *is but of yesterday, and knows nothing, because his days upon the earth are but as a shadow*) precisely and peremptorily to define all the ends and aims of the omniscient God in his great work of the creation; yet perhaps, it will be no great venture to suppose, that at least in the creating of the sublunary world, and the more conspicuous stars, two of God's principal ends were, the manifestation of his own glory, and the good of men. For the first of these; *The Lord hath made all things for himself*, says the preacher; *for of him, and through him, and to him, are all things*, says the apostle. And, *Thou hast created all things, and for thy pleasure they are and were created*, say the twenty-four prostrate elders (representatives, perhaps, of the whole church of both testaments, propagated by the twelve patriarchs, and the like number of apostles) to their Creator; which truth, were it requisite, might be further confirmed by several other texts, which, to decline needless prolixity, I here forbear to insist on. Consonantly to this, we hear the Psalmist proclaiming that *the heavens declare the glory of God, and the firmament sheweth his handy-works*. To which purpose we may also observe, that though man were not created, till the close of the sixth day (the resident's arrival being obligingly suspended till the palace was made ready to entertain him)

The end of God's creation: his own glory. Job viii. 9.

Prov. xvi. 4.

Rom. xi. 36.

Psal. xix. 2.

Job
xxxviii. 57.

Sen. de Otio
Sap. 32.

him) yet, that none of God's works might want intelligent spectators and admirers, the angels were created the first day, as divines generally infer from the words of God in Job; *Where wast thou, when I laid the foundations of the earth?* and a little after; *when the morning stars sang together, and all the sons of God shouted for joy.* Where, by the morning stars and sons of God, are supposed to be meant the newly created angels; one of whose earliest exercises was, it seems, to applaud the creation, and take thence occasion to sing hymns to the almighty author of it. I should not, *Pyrophilus*, add any thing further on this subject, but that having since the writing of these thoughts, met with a discourse of *Seneca's*, very consonant to some of them, I suppose it may tend to your delight as well as to their advantage, if I present you some of the truths you have seen in my coarser language, dressed up in his finer and happier expressions. *Curiosum nobis* (saith he) *natura ingenium dedit, & artis sibi pulchritudinisque conscia spectatores nos tantis rerum spectaculis genuit, perditura fructum sui, si tam magna, tam clara, tam subtiliter ducta, tam nitida, & non uno genere formosa solitudini ostenderet; ut scias illam spectari voluisse, non tantum aspicere, vide quem locum nobis dedit; nec erexit tantummodo hominem, sed etiam ad contemplationem factum, ut ab ortu sidera in occasum labentia prosequi posset, & vultum suum circumferre cum toto, sublime illi fecit caput, & collo flexibili imposuit.* Deinde *sena per diem, sena per noctem signa produxit; nullam non partem sui explicuit, ut per hæc, quæ obtulerat ejus oculis, cupiditatem faceret etiam cæterorum: nec enim omnia nec tanta visus quanta sunt, sed acies nostra aperit sibi investigando viam, & fundamenta veri jact, ut inquisitio transeat ex apertis in obscura, & aliquid ipso mundo inveniat antiquius:* 'Nature, ' conscious to her self of her own beauty and artifice, hath given us a curious searching ' wit, and to so excellent and great shews begat us to be spectators; otherwise she ' would have lost the fruit of herself, if to a desert and solitude she should have set forth ' so magnificent, so famous, so finely drawn, so fair and many ways beautiful pieces. ' That you may know she would not only have them seen, but looked upon, take notice of the place she hath given us: for she hath not only made man of an upright ' stature, but being so made, for better contemplation, that he might follow with his ' eye the course of the stars, from the rising to the setting, and carry about his looks, ' together with his whole body, she hath both given him a tall head, and placed that ' upon a flexible neck; then she shews fix constellations by day, and fix by night. She ' hath laid open every part of her self, that by those things, which she hath offered to ' the eyes of man, she might breed a desire of knowing the rest. Yet neither do we ' see all her works, nor those that we see, do we see in those proportions which they ' truly have; but our sight, by searching, does open a way unto it self, and lay the ' grounds of truth, that so inquiry may pass from things that are plain, to things that ' are obscure, and find somewhat more ancient, even than the world it self.' See *Sen. De Vita Beata*, cap. xxxii. And lest you might be offended at his mentioning of nature, and silence of God, give me leave to inform you, that about the close of the chapter immediately preceding that, whence the passage you come from reading is transcribed, having spoken of the enquiries of philosophers into the nature of the universe, he adds, *Hæc qui contemplatur, quid Deo præstat? ne tanta ejus opera sine teste sint:* ' What does he, that contemplates the nature of the universe, of honour unto God? ' this, that his great works are not without a witness.'

That man's
good is a
second end,
proved by
scripture.
Gen. i.
28, 29.

AND to proceed to that, which we have formerly assigned for the second end of the creation; that much of this visible world was made for the use of man, may appear, not only from the time of his creation (already taken notice of) and by the commission given to the first progenitors of mankind, *to replenish the earth and subdue it, and to have dominion over the fish of the sea, and over the fowls of the air, and over all the earth, and over every living thing that creepeth or moveth on the earth:* but also by God's making those

those noble and vast luminaries, and other bodies, that adorned the sky, to give light upon the earth, though inferiour to them in dimensions, and to divide between the day and between the night, and to be for signs, and for seasons, and for days, and for years. To this agrees that passage in the prophet, *Thus saith the Lord that created the heavens, God himself that formed the earth, and made it, He hath established it, He created it not in vain, He formed it to be inhabited, &c.* And the inspired poet speaks of man's dignity in very comprehensive terms, *For thou (says he to his Maker) hast made him little lower than the angels, and hast crowned him with glory and honour; Thou madest him to have dominion over the works of thy hands, thou hast put all things under his feet.*

Gen. i.
14, 16.
Isai. xlv. 28.
Psal. v. 5, 6.

THE same truth may be confirmed by divers other texts, which it might here prove tedious to insist on. And therefore I shall rather observe, that consonantly thereunto, God was pleased to consider man, so much more than the creatures made for him, that he made the sun it self at one time to stand still, and at another time to go back, and divers times made the parts of the universe forget their nature, or act contrary to it; and has (in sum) vouchsafed to alter by miracles the course of nature, for the instruction or relief of man (as when the fire suspended its destructive operation, whilst the three resolute Jews, with their protector, walked unharmed in the midst of those flames that destroyed the kindlers; and as the heavy iron, emerged up to the swimming piece of wood, miraculously by *Elisba* made magnetical.) And you may also, *Pyrophilus*, take notice, that when *Adam* had transgressed, immediately the ground was cursed for his sake. And as it is not unusual in human justice to raze the very houses of regicides and resembling traitors; so when the provocations of *Sodom* swelled high enough to reach heaven, God did not only destroy the inhabitants from the face of the earth, but for the inhabitants sins destroyed the very face of the earth. So when in *Noah's* time, a deluge of impiety called for a deluge of waters, God, looking upon the living creatures, as made for the use of man, stuck not to destroy them with him, and for him; but involved in his ruin all those animals, that were not necessary to the perpetuation of the species, and the sacrifice due for *Noah's* preservation. And so, when (in the last days) the earth shall be replenished with those scoffers mentioned by *St. Peter*, *who will walk after their own lusts*, and deride the expectation of God's foretold coming to judge and punish the ungodly, their impiety shall be as well punished as silenced by the unexpected flames (perhaps hastened by that very impiety) that shall either destroy or transfigure the world. For as by the law of *Moses*, the leprous garment, which could not be recovered by being washed in water, was to be burned in the fire; so the world, which the deluge could not cleanse, a general conflagration must destroy.

Gen. ii. 26,
28, 29.
Psal. viii. 7.
Heb. ii. 7.
Job v. 3.
Ho. ii. 20,
21, 22.
Rom. viii.
28.
2 Cor. iii.
22.
2 Tim. iv. 3.
2 Kings vi.
5, 6.

2 Pet. iii.
3, 5, 6, 7,
8, 10.
Lev. xiii.
54, 55.

The same
proved by
reason and
authority,
xxvi, xxvii,
xxviii.

How the sun
(*Shemeſh*)
is the great
minister of
the uni-
verse.

NOR is reason it self backward to countenance what we teach. For it is no great presumption to conceive, that the rest of the creatures were made for man, since he alone of the visible world is able to enjoy, use, and relish many of the other creatures, and to discern the omniscience, almightiness, and goodness of their author in them, and return him praises for them. It is not for themselves, that the rubies flame, other jewels sparkle, the bezoar-stone is antidotal; not is it for their own advantage, that fruitful trees spend and exhaust themselves in annual profusions. The light, which he diffuses through the world, is useles to the sun himself, whose inanimate being makes him incapable of delighting in his own splendor, which he receives but to convey it to the earth, and other by him illuminated globes: whence probably the Hebrews called him *Shemeſh*, which grammarians derive from the root *Skemaſh*, signifying, in the Chaldean tongue, *to serve*, or *minister to*; the sun being the great minister of nature, and servant general of the universe. And as animals alone, among the creatures, seem to have a proper sense of, and complacency in, their own being; so man alone among animals is endowed with reason, at least such a pitch of it, as by which he can discern God's crea-

In Probl.
de Creat.

tures to be the gifts of God, and refer them to their Creator's glory. This truth I find not only embraced by Christians, but assented to even by Jews and Heathens. Among the Jews, my learned acquaintance, *Manasseh Ben Israel*, professedly labours to prove it by scripture and tradition, (though in some of his arguments, he might appear more a philosopher, if he would have appeared less a Rabbi) and among other passages I remember he alledges that, wherein the wise man says (as our translators english it) *that the righteous is an everlasting foundation*, which he renders, *justus est columna mundi, the just man is the pillar of the world*. And indeed, if the context did not somewhat disavour the interpretation, the Hebrew words [*tzadik yesod olam*] would well enough bear the sense assigned them. Congruously whereunto, I remember, that when *Noah* (who

Prov. x. 25.
Gen. vi. 9.

2 Pet. ii. 5.

is called in scripture a righteous man, and *ἀνὴρ δίκαιος*, a *herald*, or *proclaimer of righteousness*) offered up that noble sacrifice of all the sorts of clean beasts and fowls, as a thank-offering for the reprieve of the world, God is said to have *smelled a savour of rest*, and to have resolved in his heart never to curse the ground for man's sake, but to continue the vicissitudes of summer, and winter, day, and night, &c. as long as the earth shall remain. And among the philosophers themselves, the truth we are now manifesting, has not been altogether ignored. For though *Seneca* somewhere, more witi-ly than truly, says, *Non causa mundo sumus hyemem æstatemque referendi; suas ista leges habent, quibus divina exercentur. Nimis nos suspicimus, si digni nobis videmur, propter quos tanta moveantur*: 'We are not the cause of the seasons and returns of summer and win-

Gen. viii.
21, 22.

Secundo
De Ira,
cap. 27.

ter to the world: these have their own laws, accommodated to the exercise of divine beings. We arrogate too much honour to our selves, if we esteem our selves worthy, that such vast bodies should fulfil such motions for our sakes.' Yet *Lactantius* (not to mention other authors) tells us, that the *Stoicks* generally believed the world to have been made for man. *Vera est* (says he) *sententia Stoicorum, qui aiunt nostra causa mundum fuisse constructum. Omnia enim, quibus constat, quæque generat ex se mundus, ad utilitatem hominis accommodata sunt*: 'True is the opinion of the *Stoicks*, that say, how that for our sakes the world was made; for all things, that are, and that the world doth by itself generate, are accommodated to the advantage of man.' And *Seneca* himself speaks elsewhere almost as if he had read and believed the beginning of *Genesis*: *Dii* (says he) *non per negligentiam nos genuere, quibus tam multa genuerant: cogitavit enim nos ante natura, quam fecit*: 'The gods were not careless or unconcerned in the making of man, for whom they made so many other creatures: for nature designed us, and drew us out in idea, before she made us.'

De Ira Dei,
cap. 13.

De Benef.
cap. 28.

NOR were the *Stoicks* the only philosophers, to whom the contemplation of the universe discovered this end of it. For to instance now in *Cicero* only; *Quorum igitur causâ* (says that great orator) *effectum esse mundum? Eorum scilicet animantium, quæ ratione utuntur: hi sunt dii & homines, quibus profecto nihil est melius*; 'And for whose sake then was the world made? for those beings, that have reason and intelligence, viz. gods and men, than whom, no being is more excellent.'

Secundo
De Nat.
Deor.

HAVING thus premised, *Pyrophilus*, that two of God's principal aims in the creation were the manifestation of his own glorious attributes, and the welfare of his noblest visible creature, man; it will not be perhaps difficult for you to discern, that those, who labour to deter men from sedulous enquiries into nature, do (though, I grant, design-lessly) take a course, which tends to defeat God of both those mentioned ends.

That ac-
commoda-
tion and de-
light, which
the crea-
tures might
afford man,
is much im-

For to speak, first, to the last of them, that man's external fruition of the creatures, and the delight and accommodation which they may afford him, must be highly prejudiced and impaired by his ignorance of that natural philosophy, wherein his dominion over the creatures chiefly consists, what we shall say hereafter concerning the usefulness of the knowledge of nature to human life, will sufficiently evince. But such an animal fruition

fruition (if I may so call it) of the works of nature affords not man all the good, that God designed him in them. For religion being, not only the great duty of man, but the grand instrument of his future happiness, which consists in an union with, and fruition of God, during that endless term, that shall succeed the expiration of his transitory life on earth; whatever increases or cherishes his religion, deserves to be looked on as a great contributor to his happiness. And we may therefore venture to affirm, that the knowledge of the creatures does less advantage man, as it enables him to master them, than as it assists him, by admiring and serving him, to become acceptable to their author. And whatever our distrustful adversaries are pleased to surmise to the contrary, certainly God intended, that his creatures should afford not only necessities and accommodations to our animal part, but instructions to our intellectual. The world is wont to be styled not unfitly by divines, the Christian's inn; but perchance it may be altogether as properly called his ship: for whereas both appellations suppose him a traveller, the inn, though it refresh him in his journey, does not further him in it, but rather retard his progress, by detaining him in one place; whereas a ship, not only serves the passenger for an inn when he is weary, but helps to convey him towards his journey's end. And according to this notion, to suppose, that God hath placed in the world innumerable things to feed man, and delight him, and none to instruct him, were a conceit little less injurious to God, than it were to a wise merchant, that sends persons he loves to a far country, to think, that he would furnish their cabinets with plenty of provisions, soft beds, fine pictures, and all other accommodations for their voyage, but send them to sea disprovided of sea-charts, and mariner's compasses, and other requisite helps to steer their course by to the desired harbour.

paired by
the want of
natural
philosophy.

That the
instructions
to our intel-
lectual part
are more
considerable,
than the
accommodations
we
have from
nature to
our animal
part.

AND indeed so far is God from being unwilling, that we should pry into his works, that by divers dispensations he imposes on us, little less than a necessity of studying them. For first he begins the book of scripture with the description of the book of nature, of which he not only gives us a general account, to inform us, that he made the world (since for that end, the very first verse in the bible might have sufficed) but he vouchsafes us by retail the narrative of each day's proceedings; and in the two first chapters of *Genesis*, is pleased to give nobler hints of natural philosophy than men are yet perhaps aware of. Though, that in most other places of the scripture, where the works of nature are mentioned but incidently, or in order to other purposes, they are spoken of rather in a popular than accurate manner, I dare not peremptorily deny, being unwilling to interest the reputation of Holy Writ (designed to teach us rather divinity than philosophy) in the doubtful contentions of naturalists, about such matters, as may (though the history of the creation cannot) be known by the meer light of natural reason. We may next observe, that God has made some knowledge of his created book, both conducive to the belief, and necessary to the understanding of his written one; our Saviour making it one cause of the Sadducees great error about the resurrection, that they *knew not the power of God*. And the Scripture being so full of allusions to, and comparisons borrowed from the properties of the creatures, that there are many texts not clearly intelligible without some knowledge of them; as may appear even by the first Gospel (the promise *that the seed of the woman should bruise the serpent's head, and have his heel bruised by that subtle creature*) preached to fallen man in *Paradise*, and by the representation of the world's four great monarchies, and the genius of each of them under the notion of four beasts, in *Daniel's* prophetick vision: and that often repeated precept of our great Master to his disciples is couched in an expression alluding to the properties of animals. For where he commands them to be wise as serpents, and harmless as doves, he does not only recommend to them a serpentine wariness in declining dangers, but seems also to prescribe not alone an inoffensiveness towards others

Of the
hints of
natural
philosophy
in the history
of the creation,
and other
references
to it in
other places,
30, 31.

(the conspicuousness of which quality in pigeons hath made them, though erroneously, be supposed to have no gall,) but also as harmless a way of escaping the dangers they are actually engaged in, as that of doves, who being pursued by birds of prey, endeavour to save themselves not by fight, but only by flight.

AND indeed so many of the texts in Scripture are not to be competently illustrated, without some knowledge of the properties of the creatures related to in them, that I wonder not that *Levinus Lemnius*, *Frantzius*, *Rueus*, and other learned men have thought it requisite to publish entire treatises, some of the animals, others of the stones, and others of the works of nature mentioned in Scripture. Only I could wish, that they had been as wary in their writings as commendable for their intentions, and had not sometimes admitted doubtful or fabulous accounts into comments upon that book, whose prerogative it is to teach nothing but truth.

NOR ought their labours to deter others from cultivating the same theme, for as (such is God's condescension to human weakness) most of the texts, to whose exposition physiology is necessary, may be explicated by the knowledge of the external, or at least more easily observed qualities of the creatures; so, that there are divers not to be fully understood without the assistance of more penetrating indagations of the abstrusities of nature, and the more unobvious properties of things, an intelligent and philosophical peruser will readily discern.

Now if you should put me upon telling you, *Pyrophilus*, what those attributes of God are, which I so often mention to be visibly displayed in the fabrick of the world, I can readily answer you, that though many of God's attributes are legible in his creatures, yet those, that are most conspicuous there, are his power, his wisdom, and his goodness, in which the world, as well as the bible, though in a differing, and in some points a darker way, is designed to instruct us; which, that you may not think to be affirmed gratis, we must insist a while on each of the three.

How God's
power is
conspicuous
in the crea-
tures, 32,
33, 34.

AND first, how boundless a power, or rather what an almightiness is eminently displayed in God's making out of nothing all things, and without materials or instruments constructing this immense fabrick of the world, whose vastness is such, that even what may be proved of it, can scarcely be conceived, and after a mathematical demonstration its greatness is distrusted! which yet is, I confess, a wonder less to be admired, than the power expressed by God in so immense a work, which nevertheless some modern philosophers (whose opinions I find some cabalists to countenance) suppose to be not the only production of God's omnipotence. Not to mention elephants, or whales, some of which an hyperbolist would not scruple to call moving mountains, and floating islands; and to pass by those stupendous hills, and those seas, where the light loses it self, as objects, which their nearness only represents so bulky; let us hasten to consider, that whereas the terrestrial globe we men inhabit, contains, besides all those vast kingdoms, the union of some of which constituted the world's four celebrated monarchies, those spacious (since detected) American regions, that have been deservedly styled the new world; and that whereas the common account makes the circuit of this terrestrial globe to be no less than 22600 *Italian* miles, consisting each of 1000 geometrical paces, (which number the more recent account of the accurate *Gassendus* makes amount to 26255 miles of the same measure;) whereas, I say, this globe of earth and water seems to us so vast, astronomers teach us, that it is but a point in comparison of the immensity of heaven; which they not irrationally prove by the parallaxis (or circular difference betwixt the place of a star, supposed to be taken by two observations, the one made at the centre, and the other on the surface of the earth) which *Gassendus* confesseth to be undiscernible in the fixt stars; as if the terrestrial globe were so mere a point, that it were not material, whether a fixt star be looked upon from the centre, or from the surface of the earth.

earth. This may lessen our wonder at the Ptolemæans making the sun (which seems not half a foot over) to be above a hundred sixty and six times bigger than the earth, and distant from it one thousand one hundred sixty and five semi-diameters of the earth, each of which contains, according to the aforementioned computation of *Gassendus*, 4177 miles; and at their supposing the fixt stars (whose distance the same author, as a Ptolemæan, supputes to be 19000 semi-diameters of the earth) so great, that they conclude each of the fixed or smallest magnitude to be no less than 18 times greater than the whole earth, and each star of the first or chief magnitude to exceed the terrestrial globe 108 times. And as for the Copernicans (that growing sect of astronomers) they, as their hypothesis requires, suppose the vastness of the firmament to be exceedingly greater, than the ancients believed it. For *Philippus Lansbergius*, who ventured to assign distances and dimensions to the planets and fixed stars (which *Copernicus* forbore to do) supposes as well as his master, that the great orb it self (as the Copernicans call that, in which they esteem the earth to move about the sun) though its semi-diameter be supposed to be 1500 times as great as that of the earth, is but as a point in comparison of the firmament or sphere of the fixed stars; which he supposes to be distant from the earth, no less than 28,000 semi-diameters of the great orb, that is, 42,000,000 of semi-diameters of the earth; or, according to the former computation of common miles, 175,434,000,000, which is a distance vastly exceeding that, which the Ptolemæans ventured to assign, and such as even imagination it self can hardly reach to. I confess indeed, that I am not so well satisfied with the exactness (nor perhaps with the grounds) of these kinds of computations, by reason of the difficulty I have met with in making exact celestial observations with either telescopes, or other instruments, sufficiently witnessed, by the great disparity remarkable betwixt the computations of the best artists themselves. But on the other side I am not sure, but that even the Copernicans ascribe not too great a distance to some of the fixed stars; since (for aught we yet know) those of the sixth magnitude, and those, which our telescopes discover (though our bare eyes cannot) are not really less than those of the first magnitude, but only appear so by reason of their greater distance from our eyes: as some fixed stars seem no bigger than *Venus* and *Mercury*, which are much lesser than the earth. And therefore upon such considerations, and because the modestest computation allows the firmament to be great enough to make the earth but a point in comparison of it; it will be safe enough, as well as just, to conclude with the Psalmist, *Great is the Lord, and greatly to be praised; and his greatness is unsearchable.*

Gassendus.
Inst. Astr.
l. 2. c. 13.

Gassendus.
lib. 3. cap.
11.

THE next attribute of God, that shines forth in his creatures, is his wisdom; which to an intelligent considerer appears very manifestly expressed in the world, whether you contemplate it as an aggregate or system of all natural bodies, or consider the creatures it is made up of, both in their particular and distinct natures, and in relation to each other, and the universe, which they constitute. In some of these the wisdom of God is so conspicuous, and written in such large characters, that it is legible even to a vulgar reader: but in many others the lineaments and traces of it are so delicate and slender, or so wrapt up and covered with corporeity, that it requires an attentive and intelligent peruser. So numberless a multitude, and so great a variety of birds, beasts, fishes, reptiles, herbs, shrubs, trees, stones, metals, minerals, stars, &c. and every one of them plentifully furnished and endowed with all the qualifications requisite to the attainment of the respective ends of its creation, are productions of a wisdom too limitless not to be peculiar to God: to insist on any one of them in particular (besides that it would too much swell this discourse) might appear injurious to the rest; which do all of them deserve that extensive exclamation of the Psalmist, *How manifold are thy works, O Lord; in wisdom hast thou made them all.* And therefore I shall content myself to observe

How God's
wisdom is
conspicuous
in them.

Psal. civ.
24.

Particular
observations
of the struc-
ture of hu-
man bodies.

observe in general, that, as highly as some naturalists are pleased to value their own knowledge, it can at best attain but to understand and applaud, not emulate the productions of God. For as a novice, when the curiousest watch the rarest artist can make, is taken in pieces and set before him, may easily enough discern the workmanship and contrivance of it to be excellent; but had he not been shewn it, could never have of himself devised so skilful and rare a piece of work; so, for instance, an anatomist, though when by many and dextrous dissections of human bodies, and by the help of mechanical principles and rules (without a competent skill wherein, a man can scarce be an accomplished and philosophical anatomist) he has learned the structure, use, and harmony of the parts of the body, he is able to discern that matchless engine to be admirably contrived, in order to the exercise of all the motions and functions, whereto it was designed: and yet this artist, had he never contemplated a humane body, could never have imagined or devised an engine of no greater bulk, any thing near so fitted to perform all that variety of actions we daily see performed either in or by a human body. Thus the circular motion of the blood, and structure of the valves of the heart and veins (the consideration whereof, as himself told me, first hinted the circulation to our famous *Harvey*) though now modern experiments have for the main (the modus seeming not yet so fully explicated) convinced us of them, we acknowledge them to be very expedient, and can admire God's wisdom in contriving them: yet those many learned anatomists, that have for many succeeding ages preceded both Dr. *Harvey* and *Columbus*, *Cesalpinus*, *Padre Paulo*, and Mr. *Warner*, (for each of these four last are supposed by some to have had some notion of the circulation) by all their diligent contemplation of human bodies, never dreamed (for aught appears) of so advantageous an use of the valves of the heart, nor that nimble circular motion of the blood, of which our modern circulators think they discern such excellent use, not to say, necessity.

Prov. xiii.
19, 20.

AND though it be true, that the greater works of God do as well declare his great wisdom as his power, according to that of the inspired philosopher; *The Lord by wisdom hath founded the earth, by understanding hath he established the heavens. By his knowledge the depths are broken up, and the clouds drop down the dew*; yet does not his wisdom appear less in lesser creatures; for there is none of them so little, but it would deserve a great deal of our wonder, did we attentively enough consider it. And as *Apelles* (in the story) was discovered by the skilful *Protagoras*, by so neat and slender a line, that *Protagoras*, by being scarce able to discern it, discerned it to have been drawn by *Apelles*: so God, in these little creatures, oftentimes draws traces of omniscience, too delicate to be liable to be ascribed to any other cause. I have seen elephants, and admired them less than the structure of a dissected mole, which hath better eyes than those, that will not see a designation in the dimness of its eyes (made only to see the light, not other objects by the help of it) and the unwonted posture of its feet, given it not to run on the ground, but to dig it self a way under ground. And, as despicable as their littleness makes the vulgar apt to think some creatures, I must confess my wonder dwells not so much on nature's clocks (if I may so speak) as on her watches, and is more exercised in the coyness of the sensitive plant, and the magnetical properties of a small and abject loadstone, than the bulk of the tallest oaks, or those vast rocks, made famous by shipwrecks. I have passed the *Alps*, and have seen as much to admire at in an ant-hill; and have so much wondered at the industry of those little creatures themselves, that inhabited it, that I have ceased to wonder at their having given a theme to *Solomon's* contemplation. Those vast exotick animals, which the multitude flocks to see, and which men give money to be allowed to gaze on, have had many of them less of my admiration than the little caterpillar, (as learned naturalists esteem it) to which we are beholden for silk. For (not to mention all the observables crouded by nature in

Of the eyes
and feet of
moles.

Of the silk-
worm.

in that little worm) I thought it very well deserved my wonder (when not long since I kept some of them purposely to try experiments) how this curious spinster, after he had buried himself alive in the precious tomb he had wrought for himself out of his own bowels, did cast off his former skin and legs, and, in shew, his former nature, appearing for divers days but an almost moveless maggot; till at length, divesting this second tegument also (in which nest, phoenix-like, he had been regenerated out of his own remains) he came forth (if I may so speak) out of his attiring room under another form, with wings, eyes, and legs, &c. to act a new part upon the stage of the world; which having spent some days, without feeding (that I could observe) in providing for the propagation of his species, he forsakes and dies. And I the rather mention the silk-worm, because that there have been of late divers subtle speculators, who would fain persuade us, that animals do nothing out of instinct, or, if you please, innate or seminal impressions; but spin, build nests, and perform all the other actions, for which they are admired, barely by imitation of what they have seen done by others of the same kind. But in the silk-worm (at least here in *England*) this plausible opinion will not hold: for the silk-worms I kept, were not hatched but in the spring, out of eggs laid some days in the sun; and the worms, that laid those eggs, being every one of them dead the winter before, it was impossible these new silk-worms, when they first began to spin their scarce imaginable fine web, and inclose themselves in oval balls of a very artificial figure and texture, should have wrought thus by imitation; there not having been for many months before, in the place, where they were hatched (nor perhaps in the whole country) any silk-worms alive which they might imitate. But I must leave these curious spinsters to their work, and proceed to tell you, that seas and mountains, with the other hyperboles of nature (if I may so term them) proclaim indeed God's power, but do not perhaps more manifest his wisdom, than the contrivance of some living engines, and (if I may so call them) breathing atoms, that are so small, that they are almost all workmanship; so that, as before, in the Psalmist's expression we truly said of God's greatness, *That it was unsearchable*; we may now as truly say of his wisdom in the prophet's words, and in the same text where he represents him as the Creator of the ends of the earth, *That there is no searching of his understanding*.

AND if I durst, *Pyrophilus*, make this part of this essay of a length too disproportionate to the rest, I could easily, as well as willingly, represent to you divers things, which might serve to illustrate the πολυποίκιλος σοφία τῆ Θεῆ, *manifold wisdom of God* (as *St. Paul* speaks on another occasion:) but though I dare not expatiate on this subject, yet neither dare I altogether conceal from you, that I have sometimes admired to see, what scarce imaginable variety of living engines his plastick skill (if I may so speak) has been able to produce, (especially in the waters) without scarce any other resemblance betwixt them, than that they are each of them excellent in its own kind, and compleatly furnished according to the exigency of its nature. And that, which much encreases this wonder, is the disproportion of those living engines, wherein the great [Υποτίθετο ὅτι] *Former of all things* (as the Scripture justly calls God) has been pleased to display an almost equally skilful contrivance. Amongst terrestrial animals we have the elephant, of whose stupendous vastness such strange things are related, even by eminent writers, that I know not well how either to dis-believe them, or give credit to them: and therefore we shall content our selves to mention that, which is left on record by the accurate *Gassendus* in the life of *Peireskius*. For this matchless gentleman having caused an elephant, in the year 1631, to be weighed in a scale, purposely provided, he was found to weigh, of the Roman pounds (consisting of twelve ounces a-piece) very near five thousand. And yet surely that this elephant was very far from being one of the largest of that sort of beasts, he, that shall consider the bigness and length of

That it works by instinct, and not by imitation.

Isa. xl. 28.

Eph. iii. 10.

Jer. x. 16.

Gassend. in Vit. Peireskii, lib. 4. Of the vastness of the elephant, and its disproportion to the ἀνὰτ and such like mites.

some

Some of their teeth, as they are commonly called, which are to be seen at divers places, both in *England* and elsewhere, and is not resolved not to believe the consonant relations of Eastern travellers (among whom *Linscoten* tells us, there have been some teeth found to weigh two hundred pounds a-piece, each pound consisting of twenty-four ounces) may be easily persuaded. On the other side, let us reflect upon the smallness of some terrestrial animals; and not to mention that little white creature bred in wax, which *Aristotle* calls 'Anapi', and speaks of as supposed to be the least of all living creatures whatsoever; let us consider those little mites, that are bred in mouldy cheese; for divers of these scarce amount to the weight of a grain, and every pound containing five thousand seven hundred and sixty grains; supposing each mite did weigh a whole grain, yet that formerly mentioned small elephant would exceed him near 28,800,000 times. And yet though a mite seem but a moving atom, and, unless there be divers together, is not easily discerned by the unassisted eye; yet in an excellent microscope, I have, you know, several times both seen and shewn to others, even in a gloomy day, and a disadvantageous place, not only the limbs of this little animal, but the very hair growing upon his legs. Now let us but consider, how strangely skilful and delicate a workmanship must be employed to contrive into so narrow a compass the several parts internal and external, requisite to make up this little animal; how many must go to the texture of the eyes, and other organs of sense; how many to the snout (which he has, not unlike a hog) and the several parts of it; how many to the stomach and guts, and the other inward parts addicted to the digestion of aliment, and exclusion of excrements; and, to be short, how unimaginably subtle must be the animal spirits running to and fro in nerves suitable in such little legs: and if, as we have observed them to multiply by eggs, the little creatures be hatched in those little eggs, after the manner of divers other oviparous animals, how much smaller than a hatched mite must be a mite upon the animation of its delineated parts? since in hen's eggs we have sometimes seen the chick manifestly alive, and its limbs clearly delineated, whilst yet it took up so small a portion of the egg, that both the white and the yolk (betwixt which it is generated, and not of the chalaza or treadle, as *Aquapendente* and other moderns teach) seemed to be sometimes yet intire, as well as involved in their peculiar membranes. But it is not so conspicuous in gradient animals (if I may so speak) as in swimming ones; how vastly disproportionate masses of matter the wise Former of all things can fashion into living engines. For whales are much more stupendous creatures than elephants: And not to mention what *Hartenius* (*apud Johnstonum*) tells us of twenty sorts of whales, whereof the eighteenth species, which he calls *Nordbwal*, is by him related to be ninety ells long; but what ells he means, I know not: nor to mention those less incredible accounts, which are given of the vastness of whales by our English navigators, who are wont to fish for them; I shall only set down what is related by one of the eminentest modern Lyncean philosophers*, because he speaks as an eye-witness when he tells us, that in the year 1624, there was cast upon a place near *Santa Severa*, about 30 miles from *Rome*, a dead whale of 91 palms in length, and 50 in thickness: he adds, that its mouth was 16 palms long, and ten high; in which, being opened and kept gaping, a man on horse-back might find competent room; this mouth being used to harbour a tongue of twenty palms (which may make out fifteen foot) in length. The same inquisitive writer adds, that four years before, near the island of *Corfica*, not far from the coast of *Italy*, another whale was cast, one hundred foot long, which being a female, was found to be big with a cub of thirty foot long, 1500 pound weight. But that, which will let you see, *Pyrophilus*, the disproportion betwixt these kind of fishes and common elephants, is that, which the same author adds, *that the lard only, or fat*, (as he speaks, *carnea pinguedo*) of this corpulent creature, weighed one hundred and thirty-

* *Jo. Faber.*
Lynceus in
 his exposition
 of some
 passages of
 p. 568.
 Of the vastness
 of the whale,
 and its disproportion
 to the small
 worms or
 fishes lately
 discovered
 in vinegar.

thirty-five thousand pound; that is, above twenty-seven times the weight of the whole elephant, which was caused to be weighed by *Peireskius*. And though the omnipotent Creator be able to make swimming creatures of such prodigious bigness, that the ocean itself may seem to be but a proportionate pond for such fishes; yet is the same omniscient continuer as able to make a swimming engine more slender than a cheese-mite, and so little, that the small part of a grain may out-weigh divers of them. For, *Pyrophilus*, I must here acquaint you with a strange observation, which I have been informed to have been some while since made in *Italy* by *Panarola* a famous physician in *Rome*, who is said, by the help of an excellent microscope, to have discerned in vinegar small living creatures, which he takes to be worms. The mention of so unlikely an experiment made me engage some excellent philosophers and mathematicians to assist me in examining it: but though our microscopes exceeded the best, that were brought us over from *Rome*, yet all our diligence and attention did but make them conclude, that *Panarola's* eyes had been deluded. Notwithstanding which, causing a somewhat hollow bottom of pure crystalline glass to be fitted to my microscope, I prosecuted the enquiry myself; and at length was so lucky, as not only to discover these little creatures with a microscope, but by holding the liquor in a chrystal phial, almost upon the strong flame of a candle, to discover multitudes of them with my naked eyes, as weak as they are. But though I have already convinced those, that formerly derided such observations, as not to be made with the best microscope, yet the great weakness of my sight has not permitted me to perfect my observations concerning these creatures. And therefore reserving the more particular mention of this odd observation till another time, I shall now only tell you as much as is pertinent to our present purpose; namely, that having with a certain parcel of strong white-wine vinegar (for it is not in every vinegar, that they are constantly to be found) filled up to the top thin phials, with long and slender necks; and having likewise with the same liquor filled other small crystalline phials, though short-necked, and held them betwixt my eye and the sun, or a window open towards it, or very near a great candle, I have often in these glasses, especially in their slender necks, after having a while fixed my eye on them, (attention being in this case very necessary) admirably observed great numbers (and sometimes as it were shoals) of living creatures, which seemed to be rather fishes than worms; for they swim freely up and down the liquor, and often hover about the top of it with a wriggling motion, like that of eels, to which likewise their long and slender shape resembles them. And though these swimming creatures be not all exactly of a size, yet some of them seemed slenderer than any sort of living ones, that hath hitherto been taken notice of by the unassisted eye. And I remember, that having looked in a good microscope upon one of them, and a cheese-mite, much about the same time, the fish appeared so slender, that we judged it not much thicker than one of the legs of the mite: so that considering what a vast deal of matter the great Creator can manage and fashion into a whale, and in how little room he can contrive all the parts requisite to constitute a fish, we may justly say to him in the Psalmist's language, *there is none like unto thee (O Lord) neither are there any works like unto thy works.*

Psalm
lxxxvi. 8.
How God's
goodness is
conspicuous
in his crea-
tures by his
provision of
accommo-
dations for
them all,
but especi-
ally for his
favourite,
man.
Nehem. ix. 6.

THE last of the three properties of God, which we mentioned him to have manifested in the creation, is his goodness; of which all his creatures do in their due measure partake, partly by their having a being vouchsafed them, and partly by their being preserved in it, as long as their subordination to higher purposes, and to more powerful creatures do permit, by that supporting influence of God, which keeps them from relapsing into their first nothing; according to that memorable passage, where *Nehemiah* having mentioned God as the *Creator of the heavens, the earth, the seas, and all the creatures belonging to them*, he calls him the *Preserver*, or, (as the original has it)

Psal. viii. 34.

the meliorating death of corn committed to the earth. And the royal poet learns humility, by the contemplation of the most elevated parts of nature; *When I consider* (says he) *the heavens, the work of thy fingers, the moon and stars, which thou hast ordained, what is man, that thou visitest him?* Thus you may see, that God intended the world should serve man, not only for a palace to live in, and to gaze on, but for a school of virtue, to which his philanthropy reserves such inestimable rewards, that the creatures can on no account be so beneficial to man, as by promoting his piety; by a competent degree of which, God's goodness hath made no less than eternal felicity attainable.

ESSAY III.

Containing a Continuation of the former.

That their opinion, who would deter men from the scrutiny of nature, tends to defeat God of much of that glory man should ascribe unto him.

HAVING thus, *Pyrophilus*, endeavoured to evince, that the opinion, that would deter men from the scrutiny of nature, is not a little prejudicial to man's interests, and does very much lessen the advantages he may derive from the creatures, both in relation to his accommodation in this life, and his felicity in the next; let us proceed to consider, whether the doctrine we oppose do not likewise tend, in its own nature, (though not in the intentions of its patrons) to defeat God of much of that glory, which man both ought and might ascribe to him, both for himself and the rest of the creatures. How unlikely it is, that we should be able to offer to God that glory, praise, and admiration, he both expects and merits from such a contemplation of the creatures, as, though it be requisite to the true knowledge of their nature and properties, is yet supposed either pernicious, or at least dangerous; you, *Pyrophilus*, or any other impartial person may easily determine.

Hab. ii. 2.

FOR the works of God are not like the tricks of jugglers, or the pageants, that entertain princes, where concealment is requisite to wonder; but the knowledge of the works of God proportions our admiration of them, they participating and disclosing so much of the inexhausted perfections of their author, that the further we contemplate them, the more foot-steps and impressions we discover of the perfections of their Creator; and our utmost science can but give us a juster veneration of his omniscience. And as when some country fellow looks upon a curious watch, though he may be hugely taken with the rich enamel of the case, and perhaps with some pretty landscape that adorns the dial-plate; yet will not his ignorance permit him so advantageous a notion of the exquisite maker's skill, as that little engine will form in some curious artist, who besides that obvious workmanship, that first entertains the eye, considers the exactness, and knows the use of every wheel, takes notice of their proportion, contrivance, and adaptation all together, and of the hidden springs, that move them all: so in the world, though every peruser may read the existence of a Deity, and be in his degree affected with what he sees, yet he is utterly unable to descry there those subtler characters and flourishes of omniscience, which true philosophers are sharp-sighted enough to discern. The existence of God is indeed so legibly written on the creatures, that (as the Scripture speaks in another sense) *He may run, that reads it*; that is, even a perfunctory beholder, that makes it not his business, may perceive it: but that this God hath manifested in these creatures a power, a wisdom, and a goodness worthy of himself, needs an attentive and diligent surveyor to discover. How different notions of God's wisdom do the eggs of hens produce in the ordinary eaters of them, and

and in curious naturalists, who carefully watch, and diligently observe, from time to time, the admirable progress of nature in the formation of a chick, from the first change appearing in the *cicatricula* (or little whitish speck discernible in the coat of the egg's yolk) to the breaking of the egg-shell by the perfectly hatched bird; and on nature's exquisite method in the order and fashioning of the parts, make such philosophical reflections, as you may meet with (not to mention what *Aristotle* and *Fabricius ab Aquapendente* have observed on that subject) in the ingenious treatise of generation, which our accurate and justly famous anatomist, Dr. *Higmore*, has been pleased to dedicate to me; and in the excellent Exercitations *De Ova* of that great promoter of anatomical knowledge, Dr. *Harvey*. And whereas it may be alledged, that the attributes of God, which are not taught us, but after much speculation of the world, are things, of which no man but an atheist doubts; to this it may be replied, that besides that it ill becomes the sense we ought to have of our weakness to despise any helps vouchsafed us of God to assist us to know or serve him; besides this, I say, God loving, as he deserves, to be honoured in all our faculties, and consequently to be glorified and acknowledged by the acts of reason, as well as by those of faith, there must be sure found a great disparity betwixt that general, confused, and lazy idea we commonly have of his power and wisdom, and the distinct, rational, affecting notions of those attributes, which are formed by an attentive inspection of those creatures, in which they are most legible, and which were made chiefly for that very end. The queen of *Sheba* had heard in her own country a very advantageous fame of the wisdom of *Solomon*; but when the curiosity of a personal visit made her an eye-witness of those particular both exquisite structures, and almost divinely prudent conducts and contrivances, wherein that wisdom did inimitably display it self, she then brake forth into pathetick and venerating exclamations, that acknowledged how much juster and improved a character (of his wisdom) her eyes had now given her, than formerly her ears had done.

VERY like a philosopher, methinks, does the great *Mercurius Trismegistus* (if we grant him to be author of the books ascribed to him) speak, when he tells his son, 'There can be no religion more true or just, than to know the things that are, and to acknowledge thanks for all things to him, that made them; which things I shall not cease to do.' He continues; 'Be pious and religious, O my son! for he, that does so, is the best and highest philosopher; and without philosophy, it is impossible ever to attain to the height and exactness of piety and religion.' And it was perhaps, *Pyrophilus*, to engage us to an industrious indagation of the creatures, that God made man so indigent, and furnished him with such a multiplicity of desires; so that whereas other creatures are content with those few obvious and easily attainable necessities, that nature has almost every where provided for them; in man alone, every sense has store of greedy appetites, for the most part of superfluities and dainties, that to relieve his numerous wants, or satisfy his more numerous desires, he might be obliged with an inquisitive industry to range, anatomize, and ransack nature, and by that concerned survey come to a more exquisite admiration of the omniscient Author. To illustrate this subject yet a little further, *Pyrophilus*, give me leave to observe to you, that philosophers of almost all religions have been, by the contemplation of the world, moved to consider it under the notion of a temple: *Ne adoremus* (says *Plutarch*) *elementa, calum, solem, lunam, &c. specula sunt hæc, in quibus artem illius singularem intueamur, qui mundum condidit, & adornavit; nec est alius mundus quam templum ejus*: 'Let us not venerate the elements, the heaven, the sun, the moon, &c. these are but mirrors, wherein we may behold his excellent art, who framed and adorned the world; nor is the world any thing else but his temple.' *Homines* (says *Cicero*) *tuentur*

Merc.
Trism. l. i.
Englified
by Dr.
Everard.

That philosophers of all religions have considered the world under the notion of God's temple.

and Latin, about this, but also enquired of two or three eminent herbarists, I could find neither any such virtue, nor almost any at all, ascribed by authors to that excellent plant.

Of the use
of divers
noxious con-
cretes, and
that they
contain
their own
antidotes.

AND whereas God's bounty to man in the creatures seems a little clouded and streightened by his permitting some poisonous plants and venomous animals to have a being in nature; to that it may be replied, first, that many poisonous bodies contain their own antidotes; insomuch that the diligent *Piso*, who hath had great opportunities to examine the effects of both, ventures to say, treating of the poisons and antidotes to be met with in *Brasil*, *Equidem vix dixeris, venena an Alexiteria plura sint pronata*. And a little lower, *Sic folia, flores, & fructus herbarum Tangaraca & Juquerii, venena Brasiliæ facillè prima, propriam suam unaqueque radicem oppositum habet antidotum*. And a little after, *Barbari viperarum pinguedinem & capita, tum & integra insecta, quæ vulnera intulerint, ex arte parata, audacè & felici cum successu venenatis ictibus applicant; adeoque per ipsos effectus comprobare nituntur in omni veneno contineri suam antidotum*: 'You can scarce determine, whether in these countries there are found more poisons or antidotes: the leaves, flowers, and fruits of the herbs Tangarack and Juquer, the two most potent venoms of *Brasil*, each of these hath its proper root for an opposite antidote. The Barbarians apply the fat and heads of vipers, and the whole bodies of those insects, prepared according to art, that stung or stuck any person, and that with boldness and happy success, to the wounds made by them, and so by the effects do attempt to prove, that in every venom its own antidote is contained.' And next, that the noxiousness of many (and therefore not improbably of all of them) is not so incorrigible, but that by man's art and chymical preparations, they may be made, not only innocent and harmless, but useful too. This truth, *Pyrophilus*, antimony and quicksilver, and some other noxious bodies (which men have learned to make medicinal) have already taught our modern physicians; who prescribe, even in their dispensatories, divers medicines made out of those churlish minerals, to which in the ensuing discourses you will find divers others (perhaps not inferiour) added. That opium is reckoned by physicians among poisons, I need not tell you; and yet such powerful remedies may be made with it for many desperate cases, especially in hot countries, that the good it may do, so much exceeds the harm, that physicians would be sorry there were none of it in the world. The oil of scorpions is not only antidotal against their stings, but is witnessed by experience, to be very useful to bring away the descending stone of the kidneys, and to remedy divers other mischiefs, besides those, that scorpions can do. And to these I shall need but to add one instance more, because of the nobleness of that single one, and that is the root *Mandiboca*, so common all over the *West Indies*: for nature is so far from having been a step-mother to man, in making that plant abound so much in those countries, though in its crude simplicity (as the *Helmontians* speak) it be confessedly a rank poison, that she hath scarce in any one plant been so bountiful to the Americans. For by a slight and easy preparation, which we shall hereafter mention, it affords many populous nations almost all the bread they eat, and some of them a good part of their drink; the root freed by a strong press from the noxious juice, and dried, affording them that Cassavy meal, whereof they make their bread; which by the taste and colour I could not discern to be other than good. Nor is this the only use this poisonous plant affords them; for the above-commended *Piso* gives us this short, but comprehensive character of it; *Ex Mandiboca radice maximo scatente veneno, optimum alimentum non solum, sed & antidotum concinnatur*, (lib. 3.) 'From the root *Mandiboca*, that abounds with a very potent poison, there is made not only excellent aliment, but even antidote too.' But concerning the use, that may be made of poisonous creatures, we elsewhere professedly discourse; and shall therefore

Of that
excellent
West-Indian
root *Mandi-
boca*.

now

now proceed to observe to you here, that I have not yet mentioned to you the instance, which most manifests the greatness of the good, which God intended man in the creatures. For, not content to have provided him all, that was requisite either to support or accommodate him here, he hath been pleased to contrive the world so, that (if man be not wanting to himself) it may afford him not only necessities and delights, but instructions too. For each page in the great volume of nature is full of real hieroglyphicks, where (by an inverted way of expression) things stand for words, and their qualities for letters. The Psalmist observes, *That the heavens declare the glory of God*: and, indeed, they celebrate his praises, though with a soundless voice, yet with so loud a one (and which gives us the moral of *Plato's* exploded notion of the musick of the spheres) to our intellectual ears, that he scruples not to affirm, that *there is no speech nor language, where their voice is not heard*, (or as *Junius* and *Tremellius* render it, without violence to the Hebrew text, *there is no speech nor words, yet without these their voice is understood*) and that *their line is gone throughout all the earth*: that is (as the learned *Diodati* expounds it) their writing in gross and plain draughts, and their words to the end of the world; their language having so escaped the confusion of tongues, that these natural and immortal preachers give all nations occasion to say of them, as the assembly at pentecost did of the inspired Apostles, *we do hear them speak in our tongues the wonderful works of God*.

How we are by the creatures instructed to devotion. *Psal. xix. 1.*

Act. ii. 13.

NOR can we, without listening to these sermons, derive the entire (perhaps not the chiefest) benefit designed us in the creatures. For sure that God, who hath composed us both of body and soul, hath not confined the uses of so many admirable creatures, and so much inimitable workmanship, to that ignoble part of man, which coupleth him to the beasts, with the neglect of that diviner portion, which allies him to the angels; vouchsafing to the lord of the creatures, in the fruition of this his palace, no higher prerogative, than he is pleased to allow to the brutes, that serve but to complete the variety requisite for its embellishment. Of this opinion I lately found that excellent writer, *St. Austin*, to have been before me: For, *Non debes uti oculis* (says he) *ut pecus, tantum ut videas, quæ addas ventri, non menti: utere, ut homo, intende cælum, & intende facta, & quære factorem; aspice quæ vides, & quære quem non vides, crede in eum quem non vides, propter ista quæ vides. Nolite fieri sicut equus & mulus, &c.* 'You ought not to use your eyes as a brute, only to take notice of provisions for your belly, and not for your mind: use them as a man; pry up into heaven; see the things made, and enquire the Maker; look upon those things you can see, and seek after him, whom you cannot see, and believe on him you cannot see, because of those things you see: and be not like the horse and mule, &c.'

NOR can the creatures only inform man of God's being and attributes (as we have already seen) but also instruct him in his own duties; for we may say of the world, as *St. Austin* did of the sacraments, that it is *verbum visibile*. And certainly, God hath never so confined himself to instruct men by words or types, as not to reserve himself the liberty of doing it by things: witness his appointing the rainbow to preach his goodness to all nations, and fortify the faith of mankind against the fear of a second deluge. It is something too high a saying for an heathen, that of *Plato*, where he teaches, *That the world is God's epistle, written to mankind*. For by *Solomon* God sends the *suggard* to school to the ant, to learn a provident industry. Christ commands his disciples to learn of serpents and pigeons prudence and inoffensiveness. The same divine teacher enjoins his apostles to consider the lillies, or (as some would have it) the tulips of the field, and to learn thence that difficult virtue of a distrustless reliance upon God. And *St. Paul* seems almost angry with the Corinthians, that their faith, in so abstruse mysteries as that of the resurrection, was not informed and strengthened, by considering the

D. Aug. Hom. 3.

1 Cor. xvi. 36, 37.

Gen. viii. 1.

the Enlivener of them all. And as for animals, who are more capable of enjoying, though not most of them of discerning his bounty, his goodness to them is more conspicuous. For besides that in scripture he is called the *Preserver both of man and beast*, and accordingly is said to *give food even to the young ravens that cry*, and to have, after the flood, remembered not only *Noah*, but *every living thing that was with him in the ark*; his goodness to them is apparent, by the plentiful and easily attainable provision he makes according to the exigence of their several natures, for that innumerable swarm of various birds, beasts, fishes, reptiles, and other animals, that people the terrestrial globe, and the contiguous parts of the world, and by his endowing each of them with all the qualifications requisite to the perpetuation of their species, and the preservation of their lives, as far forth as is consistent with his ends in their creation. But most resplendent does the goodness of God appear towards his favourite creature, man, whom having vouchsafed to ennoble with his own image, he makes most of the creatures of the world visible to us, pay homage to him, and in some manner or degree do him service; God's liberality at once bestowing on him all those creatures, by endowing him with a reason enabling him to make use of them; so that even those creatures, which he is not able to subdue by power, he is able to make serviceable to him by his knowledge: as those vast globes of light, which are so far above him, that their immensity and brightness can scarce render them visible to him, are by man's mathematicks forced to give him an account of all their motions, and waiting upon his dials keep time for him; and even the defects of such works of nature are by man's skill made serviceable to him, as the eclipses of the moon serve geographers notably in that difficult and useful work of finding longitudes. The stars serve for candles to give man light, and the celestial orbs are his candlesticks. He breathes the air, the fire warms him, and serves him not only in his kitchen, but to master most other bodies in his furnaces. The clouds water his land, the earth supports him and his buildings, the sea and winds convey him and his floating houses to the remotest parts of the world, and enable him to possess every where almost all that nature or art has provided for him any where. The earth produces him an innumerable multitude of beasts to feed, clothe, and carry him; of flowers and jewels to delight and adorn him; of fruits, to sustain and refresh him; of stones and timber, to lodge him; of simples, to cure him; and in sum, the whole sublunary world is but his magazine. And it seems the grand business of restless nature so to constitute and manage his productions, as to furnish him with necessities, accommodations, and pleasures.

Of such a number of plants, animals, metals, minerals, &c. that people and enrich the terrestrial globe, perhaps there is not any one, of which man might not make an excellent use, had he but an insight into its nature: nor are the most abject and despicable therefore the least useful. There is not any stone, no not the sparkling diamond it self, to whom man is so much beholden, as he is to the dark and unpromising load-stone; without which the new world probably had never been detected, and many regions of the old world would have little or no commerce with each other. Nor have the lion, the eagle, and the whale joined all together, (though reputed the chief of birds, beasts, and fishes) been so serviceable to man, as that despicable insect, the silk-worm. And if we impartially consider the lucriferosness (if I may speak in my Lord of *St. Alban's* style) of the properties of things, and their medical virtues, we shall find, that we trample upon many things, for which we should have cause to kneel, and offer God praises, if we knew all their qualities and uses. But of this subject we may elsewhere purposely treat.

To which I must only add, *Pyrophilus*, that you will injure nature, if you suppose, either that all the concretes, endowed with excellent properties, have long since been
notorious;

notorious; or that all the medicinal virtues of simples, commonly used, are already known; or that all those concretes are destitute of considerable properties, to whom none have been yet ascribed by eminent authors. For almost every day either discloses new creatures, or makes new discoveries of the usefulness of things; almost each of which hath yet a kind of *terra incognita*, or undetected part in it. How many new concretes, rich in medicinal virtues, does the new world present the inquisitive physicians of the old? *Notatu dignum* (says the ingenious *Piso*, in his new published *Medicina Brasiliensis*, lib. 1.) *quod eximia tot arbores, frutices, & innumerae herbae, figura, foliis, & fructibus à veteris orbis vegetabilibus, paucis exceptis, dissimillimae appareant. Inde de avibus, animantibus, & piscibus deprehenditur, ut & insectis alatis, atque alis destitutis, quae ineffabili colorum pulchritudine & portentosa multitudine generantur, partim nota nobis, partim incognita*: 'It is observable, that so many excellent trees, shrubs, and an innumerable company of herbs, some few excepted, should all appear so unlike the vegetables of the antiently known world, both in figure, leaf, and fruits: and the same observation is made of birds, beasts, and fishes; and of insects both flying and creeping, which are monstrously numerous, and of unspeakable beauty in colour, some known to us, and some unknown.' And of the known American simples, how many latent virtues does experience from time to time discover? And (to mention now no others) the febrifugal property of that Peruvian tree, called by the natives *Gannanaperide*, whose bark, called commonly *China febris*, has been at *Rome*, and freshly also at *London*, found so wonderfully effectual against those stubborn diseases, quartan agues; and though a learned author endeavours to depreciate it, by alledging, that it is wont rather to suspend the fits, than truly cure the disease, which after a while will return again; yet, besides that it may be often very beneficial to a weakened patient to have his fits put off, the physician thereby also gaining opportunities to imploy strengthening and preventing remedies; besides this, I say, if you will credit that great person, *Sir Kenelm Digby*, it is rather the patient's or doctor's fault, than the medicine's, if the disease return. For having purposely consulted him about this objection against the use of the *cortex febrifugus*, he solemnly assured me, that of betwixt twenty and thirty persons, that he had himself cured of quartans by this remedy, not so many as two fell into a relapse.

AND now I am upon the more freshly discovered virtues of American drugs, I might acquaint you with the admirable properties, not only in diseases, but even in wounds, of a certain mineral, which (though careful examination of it has not yet taught me, to what species of stones to reduce it) you cannot but have heard mentioned with wonder, under the name of *Sir Walter Raleigh's* stone, which my father, *ὁ παναγίτης*, enjoyed, and did strange things with for many years, and by his will bequeathed (as the highest legacy he could leave him) to his dearest friend, the most learned and famous *Bp. Usher*, Primate of *Ireland*. But of this stone, the merit of the subject makes me reserve what I have to say, to a discourse, wherein I may be allowed to say more to it than now I dare: and therefore I shall proceed to tell you, that it is not in the simples of the new world only, that new medicinal properties may be discovered; for even those, which daily obtrude themselves upon our careless eyes, or are trampled under our regardless feet, may possess virtues, to which the major part of botanists are mere strangers. To which purpose I remember, that I have often gathered a little short-lived and despicable plant, (namely *Paronychia folio rutaceo*) with which alone (slightly infused in beer) I lately knew a young kinsman of *Sir Kenelm Digby's*, in few days, and without pain, as both himself, his mother, and his physician assured me, cured of that stubborn and seldom vanquished disease of the king's evil, against which it doth wonders: and yet having consulted not only some of the famousst and recentest herbals, both English

Of the unknown and new detected properties and virtues of divers concretes.

Of the Peruvian bark, commonly called the Jesuits powder.

Of the use of *Paronychia fol. rutaceo* in the king's evil, and of divers other concretes observable for their unknown properties.

tur illum globum, quem in templo hoc medium vides, qui terra dicitur: ‘Men abide upon that globe, which you see in the middle of this temple, and is called the earth:’ which *Macrobius* handsomely thus expounds; *Quicquid humano aspectui subjicitur, templum ejus vocavit, qui sola mente concipitur, ut qui hæc veneratur ut templa, cultum tamen maximum debeat Conditore, sciatque quisquis in usum templi hujus inducitur, ritu sibi vivendum sacerdotis:* ‘All that human view reaches, he terms his temple, who is apprehended by the mind alone; to the end, that whoso reverences these things as temples, might render the greatest worship to the Maker: and every one, that is brought to converse in this temple, might know himself obliged to live like a priest.’

*Sen. lib. 7.
c. 7.*

*Philo Jud.
de Menar-
chia.*

*Heb. viii.
2, 5.*

Heb. ix. 24.

That in
this temple
man must
be the
priest.

AND the lofty *Seneca* (to mention now no other Heathens) in divers passages of his excellent writings, styles the world a temple; and I remember, in his treatise *De Beneficiis*, he avers in terms not unworthy his mind or his subject, *Totum mundum deorum esse immortalium templum, solum quidem amplitudine illorum ac magnificentia dignum:* ‘That the whole world is the temple of the immortal gods, being alone worthy of their grandeur and magnificence.’ The assent of the Jewish philosophers to this notion you may be pleased to receive from their eloquent *Philo*, who not only gives the world the name of temple, but gives us this account of that appellation; *Templum Dei supremum & verè tale existimare totum hunc mundum, qui sacrarium quidem habet, purissimam rerum nature partem, cælum; ornamenta, stellas; sacerdotes, ministros potentie ejus, angelos, & incorporeas animas:* ‘The whole world is to be accounted the chiefest temple of God; the *Sanctum Sanctorum* of it is of the purest part of the universe, heaven; the ornaments, the stars; the priests, the ministers of his power, angels, and immaterial souls.’ And as for Christian philosophers, I suppose it would be needless to enumerate the passages, wherein they adapt the notion of the world already mentioned; and therefore I shall content my self to add, that the scripture it self seems to authorise it by representing to us, in the eighth or ninth chapters of the epistle to the Hebrews, the Mosaical tabernacle, as an adumbration of that great temple of the world; and particularly there is a signal text in the latter of those chapters, where it is said, that Christ is not entered into holy places made with hands [*χειροποίητα ἅγια*] which are copies of the true, [*ἀντίτυπα τῶν ἀληθινῶν*] but into heaven it self, now to appear in the presence of God for us.

UPON what account, *Pyrophilus*, I esteem the world a temple, I may elsewhere have occasion to declare; but this for the present: it will not be rash to infer, that if the world be a temple, man sure must be the priest, ordained (by being qualified) to celebrate divine service not only in it, but for it. For as in schools, when the prince or some munificent benefactor confers some large possession or rich annuity upon the foundation, though all the boys be concerned in the benefit, yet because most of them are too young to be sensible of it, or too unlearned to be able to make the retribution of a handsome acknowledgment, either the master, or that other person of the society, who is most capable and the best spokesman, is by a kind of natural right engaged to the duty of returning praise and thanks, not for himself alone, but in the name of all the rest; so in the world, where there are so many inanimate and irrational creatures, that neither understand, how much they owe to their Creator, by owing him even themselves, nor are born to a condition enabling them to acknowledge it; man, as born the priest of nature, and as the most obliged and most capable member of it, is bound to return thanks and praises to his Maker, not only for himself, but for the whole creation. In which sense we may reconcile those two current assertions, *That God made all things for his own glory, and that God made all things for man, and man for himself.* Since whether or no man be a microcosm or little world in *Paracelsus*’s sense, if not as a ressembler, yet as a representer of the macrocosm or great world, he presents with

with his own adorations the homages of all the creatures to their Creator, though they be ignorant of what is done, as infants under the law were of the sacrifices offered on their account. And in this relation may the creatures answer the solemn invitation made them in the whole 148th Psalm, and numerous other scriptures; which they may do (to borrow a barbarous, but significant school-term) objectively, though not formally; I mean, by proving occasions, though not fingers, of his praises; being such objects, as prompt and invite man to pay God that praise upon their score, which they cannot actually pay him themselves; even God's muteſt works being capable of being ſaid to praise him in the ſame ſenſe (though in an incomparably tranſcendenter degree) that *Solomon* ſays of his virtuous woman (in the laſt verſe of the Proverbs) *Let her own works praise her in the gates*; that is, give the conſiderers of them occaſion to extol her: and thus by man's referring the knowledge of the creature to the Creator's glory, it becomes in ſome ſenſe, and congruouſly to its own nature, the praiſer of its maker, as may ſeem intimated in this oeconomy of the laſt part of one of the Psalms, *Bless the Lord, all ye his hoſts, the miniſters of his, that do his pleaſure. Bless the Lord, all his works, in all places of his dominion: bless the Lord, O my ſoul.* Where, by ſhutting up the reſt of God's creatures betwixt angels and man's ſoul, he ſeems to inſinuate, that the irrational creatures bleſs the Lord by the mouth of thoſe, that are intelligent.

Prov. xxxi.
13.

Pſal. ciii.

AND truly, *Pyrophilus*, I fear it may reſiſh a little of ſelfiſhneſs, to make ſuch a diſparity betwixt perfections, all of them equal, becauſe all of them infinite, as to let God's mercy, becauſe it moſt advantages us, ſo to ingroſs our thoughts and wonder, as to make us neglect the contemplation of thoſe other glorious attributes, his power and his wiſdom, which were thoſe, that exacted both man and angels adoration, before ſin gave occaſion to the exerciſe of the firſt. And I ſhall not ſcruple to confeſs unto you, that I dare not confine the acts of devotion to thoſe, which moſt men ſuppoſe to comprize the whole exerciſe of it: not that I at all undervalue, or would depreciate any, even the meaneſt practices of devotion, which either Scripture, or reaſon conſonant to it, recommends; but that I eſteem, that God may be alſo acceptably (and perhaps more nobly) ſerved and glorified by our entertaining of high, rational, and, as much as our nature is capable of, worthy notions, attended with a profound and proportionable admiration of thoſe divine attributes and prerogatives, for whoſe manifeſting he was pleaſed to conſtruct this vaſt fabrick.

The con-
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neglect the
glory of his
power and
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To which purpoſe I conſider, that in the life to come, when we ſhall queſtionleſs glorify God exactlieſt, we ſhall have little either need or uſe of faith, prayer, liberality, patience, and reſembling graces; but our worſhip will chiefly conſiſt in elevated notions, and a proſtrate veneration of God's omnipotence, wiſdom, goodneſs, and other perfections; and ſuch a one as this is repreſented in the *Apocalypſe*, to be the preſent imploymment of the bleſſed ſpirits in heaven, where the elders, that aſſiſt about the throne of God, are deſcribed caſting their crowns before it, and ſaying to him, that ſits on it, *Thou art worthy, O Lord, to receive glory, and honour, and power: for thou haſt created all things, and for thy pleaſure they are and were created.*

Rev. iv. ii.

By this time, *Pyrophilus*, I hope you begin to think, that the doctrine, that tends to deter men from inquiring into nature, is as well derogatory from God's glory, as prejudicial to man's intereſts. And indeed, I purpoſed to content myſelf with the having diſperſed, throughout the paſt diſcourſe, the grounds of answering their objection againſt the ſtudy of phyſiology, who pretend it is apt to make men atheiſts: but becauſe I am much concerned to have you ſatiſfied of ſo important a truth, as that, which we have hitherto been labouring to evince, I muſt beg your leave, *Pyrophilus*, to add *ex abundanti* (as they ſpeak) to what has been already alledged, ſome things,

that may more directly answer the objection of our adversaries, and manifest, how little their severity is befriended, either by Scripture, reason, or experience.

Proved further from the ancient institution of the Sabbath.

Lib. vii. c. 24.

AND first, it seems not at all probable, that if the omniscient Author of nature knew, that the study of his works did really tend to make men disbelieve his being or attributes, he would have given men so many invitations, and almost necessities, to study and contemplate the nature of his creatures. Of these invitations divers have been mentioned already, and more might be added to them, if we thought it requisite. But what has been above alledged, will make us forbear the annexing of any, save that of the ancient institution of the sabbath, which many eminent divines do not groundlessly hold to have been ordained to commemorate the creation, and give men the opportunity every seventh day to contemplate God in his works, as he himself was pleased to rest on the first seventh day, and contemplate himself in the works of the first six. And though our western churches, for certain reasons (not here to be inquired into) have long since disused the solemnizing of the Saturday, and appointed the Sunday for the celebration of both the works of the redemption, and creation of the world together; yet it is evident enough, that the primitive Christians did for the most part keep the Saturday as holy-day, as well as the Sunday: for that ancient book (whoever be resolved to have written it) which goes under the name of *Clement's Constitutions*, affords us, among others, these two memorable passages to our purpose: and first, Τὸ Σάββατον μέντοι (says he) καὶ τὴν κυριακὴν ἑορτάζετε, ὅτι τὸ μὲν δημιουργίας ἐστὶν ὑπομνημα, ἡ δὲ ἀναστάσεως. *Keep the sabbath and the Lord's day as holy days; that being dedicated to the remembrance of the creation, and this to that of the redemption.* To which we shall add this second passage of the same author, Ἐργαζέσθων οἱ δῆλοι, &c. *Let servants work for five days; but on the sabbath, and the Lord's day, let them attend in the church the doctrine of godliness.* To which purpose, I remember the most learned *Grotius* observes, that the converted emperor *Constantine* forbad the compelling Christians to appear before tribunals on either of those days, as being their festivals: Nay, and if modern travellers do not mis-inform me, I find, that divers of the eastern churches, particularly the * *Abyssine Christians*, to this day, do as well sanctify the sabbath-day in commemoration of God's having created the world, as the Lord's-day to commemorate the resurrection of Christ. And as for the Jews sense of the fourth commandment, some of the learnedest of their criticks are pleased to distinguish betwixt the words *zachôr* and *shamôr*, *remember* and *keep*, imployed in the command of solemnizing the sabbath: for, the remembering of it they hold to be an act of religion, performable by all mankind, that are capable of it, and acquainted with its having been commanded; though the keeping of it holy they suppose only enjoined to the Israelites. On which occasion I remember I was one sabbath-day entertained at his own lodgings, by a learned Jew (who taught me the holy language) with meat then newly dressed; to remove my wonder at which, he told me, 'That it was dressed by Christians, who, being Gentiles, were not obliged to the strict and legal observation of the sabbath.' But whatever be thought of this Jewish notion, yet questionless, if the fourth commandment do not, at least, divers other passages of scriptures do much discountenance their severity, who would fright men from the indagation of nature. And he, that shall duly consider divers texts obvious enough in the book of *Job*, and the *Psalms* (besides other parts of the Bible) will not readily conclude, that natural philosophy and divinity are at such variance, as the divines we deal with would persuade us. *St. Paul* seems to inform us, that the invisible things of God, from the creation of

Rom. i. 20.

* See of the Abyssine or Æthiopian Christians, and likewise of the Maronites in the East, in reference to their celebration of the Saturday, *Alex. Rossé*, in his *View of all Religions*, and the Authors by him cited.

the world, are clearly seen, being understood by the things, that are made, even *his eternal power and Godhead*: so that they, that were mentioned before, are without excuse. And though I ignore not, that not only several of the Socinians following their master *Socinus*, but some few orthodox writers, are pleased to give a very differing interpretation of that text, and make the *ἀόρατα αὐτῆς ἀπο κτίσεως κόσμου*, to signify those things of God, that have been invisible ever since the creation of the world, and referring the *ποίηματα* to things not made, as we translate it, *but done* (as the miracles of Christ and his apostles) yet I see no necessity, why the *ποίηματα* should be taken in a sense exclusive of the creation, and not at least admitted to take in all the ways and methods imployed by God, to manifest the *invisible things* there intimated unto man. And certainly, however *St. Paul* may be supposed to appear but darkly, yet *Job* was clearly of a differing opinion from theirs, who teach, *That the study of nature leads to atheism*: for ask now the beasts (says he) and they will teach thee; and the fowls of the air, and they shall tell thee; or speak to the earth, and it shall teach thee; and the fishes of the sea shall declare unto thee. Who knoweth not in all these, that the hand of the Lord hath wrought this? And consonantly hereunto (which it were not amiss for our adversaries to take notice of) we may observe; That almost all the writers of natural theology, and the most also of those, that have laboured to demonstrate the truth of Christian religion (divers of whom have been as well profound divines, as otherwise eminent scholars) have undertaken to evince, by the consideration of the universe, both that there is a God, and that he is the author of it. Which I the rather mention, *Pyrophilus*, because I would not be mistaken, as if I disputed against divines in general, or were guilty of the least irreverence towards a faculty, in whose study I have thought my self obliged, as a Christian, to spend much of my time; and especially, I would not appear disrespectful to divines in *England*, where they have already been but too much vilified, though questionless for their sins against God, yet, I fear, not without the sin of their oppressors.

Job. xii. 7, 8, 9.

IN the next place I consider, that since physiology is said to tempt to atheism, but by enabling men to give an account of the phænomena of nature, by the knowledge of second causes, without taking in the first, it will not be so easy a matter, as many presume, for the contemplation of nature, to turn a considering man atheist. For we are yet, for aught I can find, far enough from being able to explicate all the phenomena of nature by any principles whatsoever. And even of the atomical philosophers, whose sect seems to have the most ingeniously attempted it, some of the eminentest have themselves freely acknowledged to me, their being unable to do it convincingly to others, or so much as satisfactorily to themselves. And indeed, not only the generation of animals is a mystery, which all, that naturalists have said to explain it, have been far enough from depriving of that name; but we see, that to explicate all the various phænomena, that belong to that single inanimate, and seemingly homogeneous body, mercury, so as not to make any hypothesis assumed, to make out one of its properties or effects, incongruous to any other hypothesis requisite to the explanation of any of the rest, hath been hitherto found so difficult, that if our posterity be not much happier unriddlers, than our forefathers or we have been, it is like to prove a task capable of defeating the industry and attempts, I say not of more than one philosopher, but of more than one age; even our chymical tortures hitherto having, from that deluding *Proteus*, forced no confessions, that bring us not more wonder than satisfaction, and do not beget almost as many scruples, as they resolve.

That Physiologists cannot explicate by second causes all the phenomena of nature, so as to exclude the first.

ESSAY IV.

Containing a requisite Digression concerning those, that would exclude the Deity from intermeddling with Matter.

That some of the Peripatetick sect are guilty of this endeavour.

I IGNORE not, that not only *Leucippus*, *Epicurus*, and other Atomists of old, but of late some persons, for the most part adorers of *Aristotle's* writings, have pretended to be able to explicate the first *beginning of things* and the world's phænomena, without taking in, or acknowledging any divine Author of it. And therefore, though we may elsewhere, by the assistance of that author, have an opportunity to give you an account of our unsatisfiedness with the attempts made by some bold wits in favour of such pretensions; yet since the main truth we plead for in this discourse, is so nearly concerned in what hath been taught by those, that would keep God from being thought to have any share in the production of the universe, I can scarce forbear (as unwilling as I am to digress) to represent to you, on the present occasion, a few considerations, which may assist you, if not to lessen the arrogance of such persons, at least, to keep your self from thinking their evidence as great, as their confidence is wont to be. Now of the philosophers we speak of, some being Atomists, and others not, it will be requisite to say something to each of the two sorts: and because we not long since, in an illustrious company, where you, *Pyrophilus*, are not unknown, met with one of them, who avowedly grounded his opinions on the Aristotelian or vulgar physiology, we shall first recommend to you two or three considerations concerning such arrogant Peripateticks, (for I speak not of that sect in general, of which I know there are divers excellent men.)

That their hypothesis is very full of mistakes.

FIRST then, you will in many passages of the following essays, find, that divers things, that have been very magisterially taught, and confidently believed among the followers of *Aristotle*, are errors or mistakes; and that as several, even of the obvious phænomena of nature, do contradict the common Peripatetick doctrine, so divers, at least of those, that are more abstruse, are not explicable by it: and as confidently as these his followers talk of the expounding the very riddles of nature; yet I remember, that he himself somewhere (for I cannot call to mind the place) did not scruple to confess, that *As the eyes of owls are to the splendor of the day, so are those of our minds even to things obvious and manifest.*

That these excluders of the Deity make but imperfect explications of the phænomena of nature.

I SHALL next take notice, that philosophers, who scorn to ascribe any thing to God, do often deceive themselves, in thinking they have sufficiently satisfied our inquiries, when they have given us the nearest and most immediate causes of some things; whereas oftentimes the assignment of those causes is but the manifesting, that such and such effects may be deduced from the more catholick affections of things, though these be not unfrequently as abstruse, as the phænomena explicated by them, as having only their effects more obvious, not their nature better understood: as when, for instance, an account is demanded of that strange supposed sympathy betwixt quicksilver and gold; in that we find, that whereas all other bodies swim upon quicksilver, it will readily swallow up gold, and hide it in its bosom. This pretended sympathy the naturalist may explicate, by saying, that gold being the only body heavier than quicksilver of the same bulk, the known laws of the Hydrostaticks make it necessary, that gold should sink in it, and all lighter bodies swim on it. But though the cause of this effect be thus plausibly assigned, by deducing it from so known and obvious an affection

affection of bodies, as gravity, which every man is apt to think he sufficiently understands; yet will not this put a satisfactory period to a severe inquirer's curiosity, who will, perchance, be apt to alledge, that though the effects of gravity indeed be very obvious, yet the cause and nature of it are as obscure, as those of almost any phænomenon it can be brought to explicate. And that therefore he, that desires no further account, desists too soon from his inquiries, and acquiesces long before he comes to his journey's end*. And indeed, the investigation of the true nature and adequate cause of gravity, is a task of that difficulty, that in spite of aught I have hitherto seen or read, I must yet retain great doubts, whether they have been clearly and solidly made out by any man. And sure, *Pyrophilus*, there are divers effects in nature; of which though the immediate cause may be plausibly assigned, yet if we further inquire into the causes of those causes, and desist not from ascending in the scale of causes, till we are arrived at the top of it, we shall perhaps find the more catholick and primary causes of things to be either certain, primitive, general, and fixt laws of nature (or rules of action and passion among the parcels of the universal matter,) or else the shape, size, motion, and other primary affections of the smallest parts of matter, and of their first coalitions or clusters†; especially those endowed with seminal faculties or properties, or (to dispatch) the admirable conspiring of the several parts of the universe to the production of particular effects; of all which it will be difficult to give a satisfactory account, without acknowledging an intelligent author or disposer of things.

And do not explain the scale of causes unto the last cause.

AND the better to clear so weighty a truth, let us further consider on this occasion, that not only *Aristotle*, and those that, mis-led by his authority, maintain the eternity of the world, but very many other philosophers and physicians, who ascribe so much to nature, that they will not be reduced to acknowledge an author of it, are wont very much to delude both themselves and others in the account they presume to give us, as satisfactory, of the causes or reasons of very many effects. I will not instance in the magnetick properties of things, nor any of those numerous abstrusities of nature, which it is well-known that the Aristotelians are wont to refer to sympathy, antipathy, or occult qualities, and strive to put men off with empty names, whereby they do not so much lessen our ignorance, as betray their own.

Instances of things, wherein their account is not satisfactory; as 1. In the particulars, the causes of which, they assign occult qualities.

BUT I shall instance in those more obvious phænomena, of which they suppose they have given us very satisfactory accounts. If you ask one of those I speak of, whence it comes to pass, that if a man put one end of a long reed into a vessel full of water, and suck at the other end, his mouth will be immediately filled with that liquor; he will readily tell you, that the suction drawing the air out of the cavity of the reed, the water must necessarily succeed in the place deserted by the air, to prevent a vacuity abhorred by nature. If you likewise ask such a man, why too in women, about a certain age, the *purgationes menstruæ* do commonly supervene; he will think he has sufficiently answered you, when he has told you, that about that age, beginning to be ripe for procreation, nature has wisely provided, that their superfluous blood should be sent to the uterine vessels, partly to disburden the mass of blood of an useless load, and partly to contribute matter, or at least afford nourishment in case of conception. But though these solutions are wont to be acquiesced in by such as those that give them, yet I see not how they can satisfy a rigid reasoner. For not now to mention, what may be objected against them out of some modern mechanical and anatomical observations, let us a little consider, that to say, that the ascent of the water in the first problem pro-

2. When they assign nature's abhorrence of vacuity to be the cause, that water doth ascend in suction.

* Physiologo qui veritatem contemplatur ultimarum causarum cognitio non finis est, sed initium ad primas supremasque causas proficiscendi. *Plutarch. l. de primo Frigido.*

† Το πρῶτον αἰτίον ἐστὶν ἡ πρώτη ἁρμολογία. *Aristot. Eth. c. Nicom. Lib. III. cap. 8.*

ceeds from nature's detestation of a vacuity, supposes that there is a kind of *anima mundi*, furnished with various passions, which watchfully provides for the safety of the universe; or that a brute and inanimate creature, as water, not only has a power to move its heavy body upwards, contrary (to speak in their language) to the tendency of its particular nature, but knows both that air has been sucked out of the reed, and that unless it succeed the attracted air, there will follow a vacuum; and that this water is withal so generous, as by ascending, to act contrary to its particular inclination for the general good of the universe, like a noble patriot, that sacrifices his private interests to the publick ones of his country.

Whereas
the contrary
is proved
in the suc-
tion of the
quicksilver.

BUT to shew men by an easy experiment, how little attraction is performed to avoid a vacuum, I have sometimes done thus. I have taken a slender pipe of glass, of about four foot long, and putting one of the open ends of it into a vessel full of quicksilver, I have sucked as strongly as I could at the other, and caused one to watch the ascent of the quicksilver, and mark where it was at the highest, and I found not, that at one suck I could raise it up much above a foot; and having caused a couple of strong men, one after another, to suck at the same end of the same pipe, I found not, that either of them could draw it up much higher. Nor did it appear, that by repeated suction, though the upper end of the pipe were each time stopt, to hinder the relapse of the quicksilver, it could at all be raised above the seven and twenty digits, at which it used to subsist in the Torricellian experiment *de vacuo*. Whereas the same end of the tube being put into a small vessel of water, I could at one suck make the water swiftly ascend through the perpendicularly held tube into my mouth; which argues, that the ascension of liquors upon suction rather depends upon the pressure of the air (against the liquors and the sucker's chest) and their respective measures of gravity and lightness compared to that pressure, than it proceeds from such an abhorrency of a vacuum as is presumed.

3. When
they assign
the causes
of the pur-
gations
menstrue.

AND so likewise in the other question proposed, it is implied, that there is in a female body something, that knows the rule of physicians, that of a plethora, the cure is the convenient evacuation of blood; and that this intelligent faculty is wise enough also to propose to it self the double end above mentioned, in this evacuation, and therefore will not provide a quantity of blood great enough to require an excretion, nor begin it till the female be come to an age, wherein it is possible for both the ends to be obtained: and that also this presiding nature is so charitable, as, that mankind might not fail, it will make the female subject to such monthly superfluities of blood, from which experience informs us, that a whole set of diseases, peculiar to that sex, does frequently proceed. And in a word, there is a multitude of problems, especially such as belong to the use of the parts of human body, and to the causes and cures of the diseases incident thereunto; in whose explication those, we write of, content themselves to tell us, that nature does such and such a thing, because it was fit for her so to do; but they endeavour not to make intelligible to us what they mean by this nature, and how meer, and consequently brute, bodies can act according to laws, and for determinate ends, without any knowledge either of the one or of the other. Let them therefore, till they have made out their hypothesis more intelligibly, either cease to ascribe to irrational creatures such actions, as in men are apparently the productions of reason and choice, and sometimes even of industry and virtue; or else let them with us acknowledge, that such actions of creatures in themselves irrational are performed under the superintendence and guidance of a wise and intelligent author of things. But that you may not mistake me, *Pyrophilus*, it will be requisite for me, to acquaint you, in two or three words, with some of my present thoughts concerning this subject: that there are some actions so peculiar to man, upon the account of his intellect and will, that they cannot be satisfactorily explicated after the manner of the acting of meer corporeal

And when
in other
cases they
ascribe to
irrational
creatures
such actions,
as in men
are the pro-
ductions of
reason and
choice.

corporeal agents, I am very much inclined to believe. And whether or no there may be some actions of some other animals, which cannot well be mechanically explicated, I have not here leisure or opportunity to examine. But for (most of) the other phenomena of nature, methinks we may, without absurdity, conceive, that God, of whom in the scripture it is affirmed, *That all his works are known to him from the beginning*, having resolved, before the creation, to make such a world as this of ours, did divide (at least if he did not create it incoherent) that matter, which he had provided, into an innumerable multitude of very variously figured corpuscles, and both connected those particles into such textures or particular bodies, and placed them in such situations, and put them into such motions, that by the assistance of his ordinary preserving concurrence, the phenomena, which he intended should appear in the universe, must as orderly follow, and be exhibited by the bodies necessarily acting according to those impressions or laws, though they understand them not at all, as if each of those creatures had a design of self-preservation, and were furnished with knowledge and industry to prosecute it; and as if there were diffused through the universe an intelligent being, watchful over the publick good of it, and careful to administer all things wisely for the good of the particular parts of it, but so far forth as is consistent with the good of the whole, and the preservation of the primitive and catholick laws established by the supreme cause; as in the formerly mentioned clock of *Straßburg*, the several pieces making up that curious engine are so framed and adapted, and are put into such a motion, that though the numerous wheels, and other parts of it, move several ways, and that without any thing either of knowledge or design; yet each performs its part in order to the various end, for which it was contrived, as regularly and uniformly as if it knew and were concerned to do its duty. And the various motions of the wheels and other parts concur to exhibit the phenomena designed by the artificer in the engine, as exactly as if they were animated by a common principle, which makes them knowingly conspire to do so, and might, to a rude Indian, seem to be more intelligent than *Conradus Diasypodius* himself, that published a description of it; wherein he tells the world, that he contrived it, who could not tell the hours, and measure time so accurately as his clock. And according to this notion, if you be pleased to bear it in your memory, *Pyrophilus*, you may easily apprehend in what sense I use many common phrases, which custom hath so authorized, that we can scarce write of physiological subjects, without employing either of them, or frequent and tedious circumlocutions in their stead. Thus when I say, that a stone endeavours to descend towards the center of the earth, or that being put into a vessel of water, it affects the lowest place; I mean, that not such a mathematical point as the center of the earth hath power to attract all heavy bodies, the least of which, it being a point, it cannot harbour; or that a stone does really aim at that unknown and unattainable center: but that, as we say, that a man strives or endeavours to go to any place, at which he would quickly arrive, if he were not forcibly hindered by some body, that holds him fast where he is, and will not let him go; so a stone may be said to strive to descend, when either by the magnetical steams of the earth, or the pressure of some subtile matter incumbent on it, or by what ever else may be the cause of gravity, the stone is so determined to tend downwards, that if all impediments, interposed by the neighbouring bodies, were removed, it would certainly and directly fall to the ground; or being put into a vessel with water, or any other liquor much less heavy than itself (for on quicksilver, which is heavier, stones will swim) the same gravity will make it subside to the bottom of the vessel, and consequently thrust away its bulk of water, which though heavy in it self, yet because it is less ponderous than the stone, seems to be light. And so in our late instance in the clock, if it be said, that the hand, that points at the hours, affects a circular

Art. xv. 18.

The author's conceit concerning God's creation of the parts of the world, and so placing them, that they (by the assistance of his ordinary concurrence) must needs exhibit these phenomena.

Illustrated by the motions of the clock at *Straßburg*.

How far such borrowed and metaphorical phrases, which custom has authorized, may be used.

Quicksilver being heavier than stones, they swim thereon, yet sink in lighter liquors.

That the instances of the action of divers creatures, resembling reason, commend the wisdom of God.

circular motion, because it constantly moves round the center of the dial-plate, it is evident, that the inanimate piece of metal affects not that motion more than any other, but only, that the impression it receives from the wheels, and the adaptation of the rest of the engine, determine it to move after that manner. And though if a man should with his finger stop that index from proceeding in its course, it may be said, in some sense, that it strives or endeavours to prosecute its former circular motion; yet that will signify no more, than that by virtue of that contrivance of the engine, the index is so impelled, that if the obstacle, put by the finger of him that stops it, were taken away, the index would move onwards, from that part of the circle where it was stopt, towards the mark of the next hour. Nor do I, by this, *Pyrophilus*, deny, that it may in a right sense be said, as it is wont to be in the schools, that *Opus naturæ est opus intelligentiæ*: neither do I reject such common expressions as *nature always affects and intends that which is best*, and *nature doth nothing in vain*. For since I must, according to the above mentioned notion, refer many of the actions of irrational creatures to a most wise Disposer of things, it can scarce seem strange to me, that in those particulars, in which the author intended, as it was requisite, that irrational creatures should operate so and so for their own preservation, or the propagation of their species, or the publick good of the universe, their actions being ordered by a reason transcending ours, should not only oftentimes resemble the actings of reason in us, but sometimes even surpass them. As in effect we see silk-worms and spiders can, without being taught, spin much more curiously their balls and webs, than our best spinsters could; and that several birds can build and fasten their nests more artificially, than many a man, or perhaps any man could frame and fasten such little and elaborate buildings. And the industries of foxes, bees, and divers other beasts, are such, that it is not much to be wondered at, that those creatures should have reason ascribed to them by divers learned men; who yet perhaps would be less confident, if they considered how much may be said for the immortality of all rational souls, and that the subtil actings of these beasts are determined to some few particulars requisite for their own preservation, or that of their species; whereas, on all other occasions, they seem to betray their want of reason, and by their voice and gestures seem to express nothing, but the natural passions, and not any rational or logical conceptions. And therefore, as when (to resume our former comparison) I see in a curious clock, how orderly every wheel and other parts perform its own motions, and with what seeming unanimity they conspire to shew the hour, and accomplish the other designs of the artificer; I do not imagine, that any of the wheels, &c. or the engine it self is endowed with reason, but commend that of the workman, who framed it so artificially. So when I contemplate the actions of those several creatures, that make up the world, I do not conclude the inanimate pieces, at least, that it is made up of, or the vast engine it self, to act with reason or design, but admire and praise the most wise Author, who by his admirable contrivance can so regularly produce effects, to which so great a number of successive and conspiring causes are required.

AND thus much, *Pyrophilus*, having been represented concerning those, that rejecting from the production and preservation of things all but nature, yet embrace the principles of the vulgar philosophy, you will perhaps think it more than enough; but object, that what is not to be expected from the barren principles of the schools, may yet be performed by those atomical ones, which we ourselves have, within not very many pages, seemed to acknowledge ingenious. And I know indeed, that the modern admirers of *Epicurus* confidently enough pretend, that he and his expositors have already, without being beholden to a Deity, clearly made out, at least the origin of the world, and of the principal bodies it is made up of. But I confess, I am so far from being convinced of this, that I have been confirmed rather, than unsettled in my opinion of the

the difficulty of making out the original of the world, and of the creatures, especially the living ones, that compose it, by considering the accounts which are given us of the nativity (if I may so speak) of the universe, and of animals, by those great deniers of creation and providence, *Epicurus*, and his paraphrast *Lucretius*: whose having shown themselves (as I freely confess they have) very subtle philosophers in explicating divers mysteries of nature, ought not so much to recommend to us their impious errors about the original of things, as to let us see the necessity of ascribing it to an intelligent cause. This then is the account of this matter, which is given us by *Epicurus* himself, in that epistle of his to *Herodotus*, which we find in *Diogenes Laertius*: *Quod ad meteora attinet, existimari non oportet, aut motum, aut conversionem, aut eclipsin, aut ortum occasumvè, aut alia hujusmodi ideo fieri, quod sit præfatus aliquis, qui sic disponat, disposueritvè, ac simul beatitudinem immortalitatemque possideat*: ‘As to the meteors, you ought not to believe, that there is either motion, or change, or eclipse, or the rise or setting of them, because of any superior president, which doth, or hath so disposed of it, and himself possesses all the while happiness and immortal life.’ And having interposed some lines, to prove, that the providence of God is not consistent with his felicity, he adds, *Quare opinandum est, tum cum mundus procreatus est, factos fuisse eos circumplexus convolvendum se atomorum, ut nata fuerit hæc necessitas, quâ circuitus tales obierint*: ‘Wherefore you must think, that when the world was made, those implications and foldings of atoms happened, which caused this necessity, that these bodies should pass through these motions.’ And elsewhere in the same epistle: *Infiniti (says he) sunt mundi, alii similes isti, alii vero dissimiles. Quippe atomi cum sint infinite, ut non multo ante demonstratum est per infinitatem spatiorum, & alibi aliæ, ac procul ab hoc ad fabrefactionem mundorum infinitorum variè concurrunt*. ‘There are infinite worlds, some like this, some unlike it: for since atoms are infinite (as I newly shewed from the infiniteness of the spaces) some in one, other in others, distant parts of these spaces far from us, variously concur to the making of infinite worlds.’ And lest this Epicurean explication of the world’s original should seem to owe all its unsatisfactoriness to its obscure brevity, we shall not scruple to give you that elegant paraphrase and exposition of it, which *Lucretius* has delivered in his 5th book, *De Rerum Natura*:

Defects in the explication of nature by the Epicureans, who deny the concurrence of God.

*Sed quibus ille modis, conjectus materiæ
Fundarit cælum, ac terram pontique profunda
Solis, lunæ cursus ex ordine ponam,
Nam certe neque consiliis primordia rerum
Ordine se quæque atque sagaci mente locarunt,
Nec quos quæque darent motus pepigere profectò:
Sed quia multa modis multis primordia rerum
Ex infinito jam tempore percita plagis,
Ponderibusque suis, consuerunt concita ferri,
Omnimodisque cõire, atque omnia pertentare,
Quæcunque inter se possent congressa creare;
Propterea fit, ut magnum volgata per ævum,
Omnigenos cætus & motus experiundo,
Tandem conveniant: ea quæ conjuncta repente
Magnarum rerum fiant exordia sæpè
Terræ maris, & cæli generisque animantum.*

' But how at first, when matter thus was whirl'd,
 ' Heaven, earth, and sea, the high and lower world,
 ' The sun and moon, and all were made, I'll shew,
 ' For sure the first rude atoms never knew
 ' By sage intelligence, and counsel grave,
 ' T' appoint the places, that all beings have :
 ' Nor will I think, that all the motions here
 ' Order'd at first by fixt agreements were,
 ' But th' elements, that long had beat about,
 ' Been buffeted, now in, now carried out :
 ' Screwed into every hole, and tried to take
 ' With any thing, in any place to make
 ' Somewhat at last ; after much time and coil,
 ' Motions and meetings, and a world of toil
 ' Made up this junto. And thus being join'd,
 ' And thus in kind embraces firmly twin'd,
 ' And link'd together, they alone did frame,
 ' Heaven, earth, and sea, and the creatures in the fame.'

THE hypothesis expressed in these verses (which please our author so well, that he has almost the same lines in several other places of his poem) he prosecutes and applies to some particular parts of the universe in the same 5th book : but whilst he thus refuseth to allow God an interest in the world's production, his hypothesis requires, that we should allow him several things, which he doth assume, not prove : as first, that matter is eternal. 2. That from eternity it was actually divided, and that into such insensibly small parts, as may deserve the name of atoms ; whereas it may be supposed, that matter, though eternal, was at first one coherent mass, it belonging to matter to be divisible, but not so of necessity, to be actually divided. 3. That the number of these atoms is really infinite. 4. That these atoms have an *inane infinitum* (as the Epicureans speak) to move in. 5. That these atoms are endowed with an almost infinite variety of determinate figures, some being round, others cubical, others hooked, others conical, &c. whereas not to mention beforehand what we may elsewhere object besides against this assumption, he shews not why, nor how this atom came to be spherical rather than conical, and another hooked rather than pyramidal : but these assumptions I insist not on, because of two others much more considerable, which our author is fain to take for granted in his hypothesis. For 6thly, he supposes his eternal atoms to have from eternity been their own movers, whereas it is plain, that motion is no way necessary to the essence of matter, which seems to consist principally in extension : for matter is no less matter when it rests, than when it is in motion ; and we daily see many parcels of matter pass from the state of motion to that of rest, and from this to that, communicating their motion to matter that lay still before, and thereby losing it themselves. Nor has any man, that I know, satisfactorily made out how matter can move itself : and indeed, in the bodies, which we here below converse withal, we scarce find, that any thing is moved but by something else ; and even in these motions of animals, that seem spontaneous, the will or appetite doth not produce the motion of the animal, but guide and determine that of the spirits, which by the nerves move the muscles ; and so the whole body, as may appear by the weariness and unwieldiness of animals, when by much motion the spirits are spent. And accordingly I find that *Anaxagoras*, though he believed, as *Aristotle* did after him, that matter was eternal, yet he discerned, that the notion of matter not necessarily including motion, there was a necessity

necessity of taking in a *mens*, as he styles God, to set this sluggish matter a moving. And I remember *Aristotle* himself, in one place of his *Metaphysics*, disputing against some of the ancient philosophers, asks, *Quonamque modo movebuntur, si nulla erit actu causa? non enim ipsa materia seipsam movebit, ἀλλὰ τεκτονικὴν rerum opifex virtus*: ‘How shall things be moved, if there be no actual cause? For matter cannot move itself, but requires to be moved by a tectonick thing, creating power.’ But though elsewhere I have met with passages of his near of kin to this, yet he seems not to express his opinion uniformly and clearly enough to engage me to define it, or make a weapon of it: and therefore I shall rather proceed to take notice, that, according to the *Epicurean* hypothesis, not only the motion, but the determination of that motion is supposed. For *Epicurus* will have his atoms move downwards, and that not in parallel lines, lest they should never meet to constitute the world, but according to lines somewhat inclining towards one another; so that there must be not only motion, but gravity in atoms, before there be any center of gravity for them to move towards; and they must move rather downwards than upwards, or sideways, and in such lines as nothing is produced capable of confining them to. Which are assumptions so bold and precarious, that I find some, even of his admirers, to be ashamed of them: which will save me the labour of arguing against them, and allow me to take notice in the seventh place, that this *Epicurean* doctrine supposes, that a sufficient number of atoms, and their motion downwards, being granted, there will need nothing but their fortuitous concurrence in their fall, to give a being to all those bodies, that make up the world. Indeed, that the various coalitions of atoms, or at least small particles of matter, might have constituted the world, had not been perhaps a very absurd opinion for a philosopher, if he had, as reason requires, supposed, that the great mass of lazy matter was created by God at the beginning, and by him put into a swift and various motion, whereby it was actually divided into small parts of several sizes and figures, whose motion and crossings of each other were so guided by God, as to constitute, by their occurrences and coalitions, the great inanimate parts of the universe, and the seminal principles of animated concretions. And therefore I wonder not much, that the *Milesian Thales* (the first of the Grecian philosophers, as *Cicero* informs us, that inquired into these matters) should hold that opinion, which *Tully* expresses in these words: *Aquam dixit esse initium rerum, Deum autem eam mentem, quæ ex aqua cuncta finxerat*: ‘He said, water was the principle of all things, but God was that intelligence, that made all things out of water.’ And that of *Anaxagoras* the same author should give us this account; *Omnium rerum descriptionem & modum mentis infinitæ vi ac ratione designari & confici voluit*: ‘The delineation and manner of all things he thought to be designed and made by the power and reason of infinite intelligence.’ For though these great men exceedingly erred, in thinking it necessary, that God should be provided of a pre-existent, and by him not created matter, to make the world of; yet at least they discerned and acknowledged the necessity of a wise and powerful agent, to dispose and fashion this rude matter, and contrive it into so goodly a structure, as we behold, without imagining with *Epicurus*, that chance should turn a chaos into a world. And really it is much more unlikely, that so many admirable creatures, that constitute this one exquisite and stupendous fabrick of the world, should be made by the casual confluence of falling atoms, jostling or knocking one another in the immense vacuity, than that in a printer’s working-house a multitude of small letters, being thrown upon the ground, should fall disposed into such an order, as clearly to exhibit the history of the creation of the world, described in the third or fourth first chapters of *Genesis*; of which history, it may be doubted, whether chance may ever be able to dispose the fallen letters into the words of one line. I ignore not, that sometimes odd figures,

Aristot.
Metaphys.
lib. 12. c. 6.

De Nat.
Deorum.
lib. 1.

Idem ibi.
dem.

and almost pictures, may be met with, and may seem casually produced in stones, and divers other inanimate bodies; and I am so far from denying this, that I may elsewhere have opportunity to shew you, that I have been no careless observer of such varieties.

That the figures in nitre, crystal, and divers minerals are produced, not by chance, but by somewhat analogous to seminal principles.

BUT first, even in divers minerals, as we may see in nitre, crystal, and several others, the figures, that are admired, are not unquestionably produced by chance, but perhaps by something analogous to seminal principles, as may appear by their uniform regularity in the same sort of concretion, and by the practice of some of the skilfullest of the salt-petre men, who, when they have drawn as much nitre as they can out of the nitrous earth, cast not the earth away, but preserve it in heaps for six or seven years; at the end of which time, they find it impregnated with new salt-petre, produced chiefly by the seminal principle of nitre implanted in that earth. To prove, that metalline bodies were not all made at the beginning of the world, but have some of them a power, though slowly, to propagate their nature, when they meet with a disposed matter; you may find many notable testimonies and relations in a little book of *Physico-chymical Questions*, written by Jo. Conradus Gerbardus, a German doctor, and most of them recited (together with some of his own) by the learned Sennertus. But lest you should suspect the narratives of these authors, as somewhat partial to their fellow-chymists opinions, I shall here annex that memorable relation, which I find recorded by *Linschotten*, and *Garcias ab Horto*, a pair of unsuspected writers in this case, concerning diamonds; whereby it may appear, that the seminal principles of those precious stones, as of plants, are lodged in the bowels of the mine they grow in. *Diamonds* (says the first, in that chapter of his travels, where he treats of those jewels) *are digged like gold out of mines; where they digged one year the length of a man into the ground, within three or four years after, there are found diamonds again in the same place, which grow there; sometimes they find diamonds of 400 or 800 grains.* *Adamantes* (says the latter) *qui altissimè in terræ visceribus, multisque annis perfici debebant in summo ferè solo generantur, & duorum aut trium annorum spatio perficiuntur: nam si in ipsa fodina hoc anno ad cubiti altitudinem fodias, adamantes reperies. Post biennium rursus illic excavato ibidem, invenies adamantes.* ‘Diamonds, which ought to be brought to perfection in the deepest bowels of the earth, and in a long tract of time, are almost at the top of the ground, and in three or four years space made perfect. For if you dig this year but the depth of a cubit, you will find diamonds; and after two years dig there, you will find diamonds again.’ And next, how inconsiderable, alas! are these supposed productions of chance, in comparison of the elaborate contrivances of nature in animals? since in the body of man, for instance, of so many hundred parts it is made up of, there is scarce any, that can be either left out, or made otherwise than as it is, or placed elsewhere than where it is, without an apparent detriment to that curious engine; some of whose parts, as the eye, and the valves of the veins, would be so unfit for any thing else, and are so fitted for the uses, that are made of them, that it is so far from being likely, that such skilful contrivances should be made by any being not intelligent, that they require a more than ordinary intelligence to comprehend how skilfully they are made.

Seeml. in India nascendi, lib. 1. cap. 47.

That the generation of animals is much less to be accounted the production of chance.

As for the account that *Lucretius*, out of *Epicurus*, gives us of the first production of men, in I know not what wombs adhering to the ground, and which much more becomes him as a poet, than as a philosopher; I shall not here waste time to manifest its unlikeliness, that witty father *Laëtantius**, having done already that copiously for me. And indeed it seems so pure a fiction, that, were it not, that the hypothesis he

* Tanta ergo qui videat, & talia potest existimare nullo affecta esse consilio, nulla providentia, nulla ratione divina, sed ex atomis subtilibus exiguis concreta esse tanta miracula? Nonne prodigio simile est, aut natum esse hominem, qui hæc diceret, ut Leucippum aut extitisse qui crederet, ut Democritum, qui auditor ejus fuit, vel Epicurum in quem vanitas omnis de Leucippi fonte profluxit. Lib. II. cap. 11.

took upon him to maintain, could scarce afford him any less extravagant account of the original of animals, the unsuitableness of this romance to those excellent notions, with which he has enriched divers other parts of his works, would make me apt to suspect, that when he writ this part of his poem, he was in one of the fits of that frenzy, which some, even of his admirers, suppose him to have been put into by a philtre, given him by his, either wife or mistress, *Lucilia*; in the intervals of which, they say, that he writ his books.

AND here let us further consider, that as confidently as many atomists, and other naturalists, presume to know the true and genuine causes of the things they attempt to explicate; yet very often the utmost they can attain to, in their explications, is, that the explicated phænomena may be produced after such a manner, as they deliver, but not that they really are so. For as an artificer can set all the wheels of a clock a going, as well with springs as with weights; and may with violence discharge a bullet out of the barrel of a gun, not only by means of gunpowder, but of compressed air, and even of a spring: so the same effects may be produced by divers causes different from one another; and it will oftentimes be very difficult, if not impossible, for our dim reasons to discern surely, which of these several ways, whereby it is possible for nature to produce the same phænomena, she has really made use of to exhibit them. And sure, he, that in a skilful watch-maker's shop shall observe, how many several ways watches and clocks may be contrived, and yet all of them shew the same things; and shall consider how apt an ordinary man, that had never seen the inside but of one sort of watches, would be to think, that all these are contrived after the same manner, as that, whose fabrick he has already taken notice of; such a person, I say, will scarce be backward to think, that so admirable an engineer as nature, by many pieces of her workmanship, appears to be, can, by very various and differing contrivances, perform the same things; and that it is a very easy mistake for men to conclude, that because an effect may be produced by such determinate causes, it must be so, or actually is so. And as confident as those we speak of use to be, of knowing the true and adequate causes of things, yet *Epicurus* himself, as appears by ancient testimony, and by his own writings, was more modest, not only contenting himself, on many occasions, to propose several possible ways, whereby a phænomenon may be accounted for, but sometimes seeming to dislike the so pitching upon any one explication, as to exclude and reject all others: and some modern philosophers, that much favour his doctrine, do likewise imitate his example, in pretending to assign not precisely the true, but possible causes of the phænomenon they endeavour to explain. And I remember, that *Aristotle* himself (whatever confidence he sometimes seems to express) does in his first book of *Meteors* ingenuously confess, that concerning many of nature's phænomena, he thinks it sufficient, that they may be so performed as he explicates them. But granting, that we did never so certainly know, in the general, that these phænomena of nature must proceed from the magnitudes, figures, motions, and thence resulting qualities of atoms, yet we may be very much to seek as to the particular causes of this or that particular effect or event. For it is one thing to be able to shew it possible, for such and such effects to proceed from the various magnitudes, shapes, motions, and concretions of atoms; and another thing to be able to declare what precise, and determinate figures, sizes, and motions of atoms, will suffice to make out the proposed phænomena, without incongruity to any others to be met with in nature: as it is one thing for a man ignorant of the mechanicks to make it plausible, that the motions of the famed clock at *Straßburg*, are performed by the means of certain wheels, springs, and weights, &c. and another to be able to describe distinctly the magnitude, figures, proportions, motions, and,

That the hypotheses of philosophy only shew, that an effect may be produced by such a cause, not that it must.

That to a perfect knowledge there must not only appear the possible, but the definite and real; not only the general, but the particular causes.

and, in short, the whole contrivance either of that admirable engine, or some other capable to perform the same things.

NAY, a lover of disputing would proceed farther, and question that way of reasoning, which even the eminentest atomists are wont to imploy to demonstrate, that they explicate things aright.

Some defects in the ways of reasoning used by the most eminent atomists.

FOR the grand argument, by which they use to confirm the truth of their explications, is, that either the phænomenon must be explicated after the manner by them specified, or else it cannot at all be explicated intelligibly: in what sense we disallow not, but rather approve this kind of ratiocination, we may elsewhere tell you. But that, which is in this place more fit to be represented, is, that this way of arguing seems not in our present case so cogent, as they, that are wont to employ it, think it to be: for besides, that it is bold to affirm, and hard to prove, that what they cannot yet explicate by their principles, cannot possibly be explicated by any other men, or any other philosophy; besides this, I say, that which they would reduce their adversaries to, as an absurdity, seems not to deserve that name. For supposing the argument to be conclusive, that either the proposed explication must be allowed, or men can give none at all, that is intelligible; I see not what absurdity it were to admit of the consequence. For who has demonstrated to us, that men must be able to explicate all nature's phænomena, especially since divers of them are so abstruse, that even the learnedest atomists scruple not to acknowledge their being unable to give an account of them. And how will it be proved, that the omniscient God, or that admirable contriver, Nature, can exhibit phænomena by no ways, but such as are explicable by the dim reason of man? I say explicable, rather than intelligible; because there may be things, which though we might understand well enough, if God, or some more intelligent being than our own, did make it his work to inform us of them, yet we should never of our selves find out those truths. As an ordinary watch-maker may be able to understand the curiousest contrivance of the skilfullest artificer, if this man take care to explain his engine to him, but would never have understood it, if he had not been taught: whereas to explicate the nature and causes of the phænomena we are speaking of, we must not only be able to understand, but to investigate them.

AND whereas, it is peremptorily insisted on by some Epicureans, who thereby pretend to demonstrate the excellency and certainty of their explications, that, according to them, nature is declared to produce things, in the way that is most facile and agreeable to our reason: it may be replied, that what we are to inquire after, is, how things have been, or are really produced; not whether or no the manner of their production be such, as may the most easily be understood by us: for if all things were, as those we reason withal maintain, casually produced, there is no reason to imagine, that chance considered what manner of their production would be the most easily intelligible to us. And if God be allowed to be, as indeed he is, the author of the universe, how will it appear that he, whose knowledge infinitely transcends ours, and who may be supposed to operate according to the dictates of his own immense wisdom, should, in his creating of things, have respect to the measure and ease of human understandings; and not rather, if of any, of angelical intellects? So that whether it be to God or to chance, that we ascribe the production of things, that way may often be fittest or likeliest for nature to work by, which is not easiest for us to understand.

AND as for the way of arguing, so often imployed (especially against the truth we now contend for) and so much relied on by many modern philosophers, namely, that they cannot clearly conceive such or such a thing proposed, and therefore think it fit to be rejected; I shall readily agree with them, in the not being forward to assent to any thing, especially in philosophy, that cannot well be conceived by knowing and considering

sidering men. But there is so much difference among men, as to their faculty of framing distinct notions of things, and through men's partiality or laziness, many a particular person is so much more apt, than these men seem to be aware of, to think, or at least to pretend, that he cannot conceive, what he has no mind to assent to, that a man had need be wary, how he rejects opinions, that are impugned only by this way of ratiocination: by which, I hope, it will not be expected, that we should be more prevailed with, than that sect of philosophers that employs it most. And among those, that resolve the phaenomena of nature into the mechanical powers of things, or the various figures, sizes and motions of the parts of matter, I meet with some, as the Epicureans, who tell us, they cannot frame a notion of an incorporeal substance or spirit, nor conceive how, if the soul were such, it could act upon the body: and yet others, that seem no less speculative, seriously and solemnly profess, that they can conceive a clear and distinct notion of a spirit, which they believe the human soul, that regulates at least, if not produces divers motions of the body, to be; denying on the other side, that it can be clearly conceived, either that any thing, that is only material, can think, or that there can possibly be any vacuum (that is, place without any body) in the universe; both which the Epicureans profess themselves not only to conceive as possible, but believe as true.

AND thus much, *Pyrophilus*, it may suffice to have said in relation to those, who would reject God from having any thing to do, either in the production or government of the world, upon this ground, that they, if you will believe them, can explicate the original and phaenomena of it without him; but it is not all, nor the greatest part of the favourers of the atomical philosophy, that presume so much of themselves, and derogate so much from God. To say therefore something to the more moderate and judicious of that persuasion, we will candidly propose on their behalf the most plausible objection we can foresee, against the truth we have been all this while pleading for. They may then thus argue against us, that though the atomists cannot sufficiently demonstrate from what natural causes every particular effect proceeds, and satisfactorily explicate after what determinate manner each particular phaenomenon is produced; yet it may suffice to take away the necessity of having recourse to a Deity, that they can make out in general, that all the things, that appear in the world, may, and must be performed by meerly corporeal agents; or, if you please, that all nature's phaenomena may be produced by the parcels of the great mass of universal matter, variously shaped, connected, and moved. As a man, that sees a screwed gun shot off, though he may not be able to describe the number, bigness, shape, and co-aptation of all the pieces of the lock, stock, and barrel, yet he may readily conceive, that the effects of the gun, how wonderful soever they may seem, may be performed by certain pieces of steel, of iron, and some parcels of wood, of gunpowder, and of lead, all fashioned and put together according to the exigency of the engine; and will not doubt, but that they are produced by the power of some such mechanical contrivance of things purely corporeal, without the assistance of spiritual or supernatural agents.

The most plausible argument of the opposers of a Deity considered.

IN answer to this objection, I must first profess to you, that I make great doubt, whether there be not some phaenomena in nature, which the atomists cannot satisfactorily explain by any figuration, motion, or connection of material particles whatsoever: for some faculties and operations of the reasonable soul in man are of so peculiar and transcendent a kind, that as I have not yet found them solidly explicated by corporeal principles, so I expect not to see them in haste made out by such. And if a spiritual substance be admitted to enter the composition of and to act by and upon his body; besides that one of the chief and fundamental doctrines of the Epicureans (namely, that there is nothing in the universe but *corpus* and *inane*) will thereby be sub-

verted,

verted, it will appear, that an incorporeal and intelligent being may work upon matter, which would argue, at least a possibility, that there may be a spiritual Deity, and that he may intermeddle with, and have an influence upon the operations of things corporeal. But to insist no longer on this, let us give a further and direct answer to the proposed objection, by representing, that although as things are now established in the world, an atomist were able to explain the phenomena we meet with, by supposing the parts of matter to be of such sizes, and such shapes, and to be moved after such a manner, as is agreeable to the nature of the particular phenomenon to be thereby exhibited; yet it would not thence necessarily follow, that, at the first production of the world, there was no need of a most powerful and intelligent being, to dispose that chaos or confused heap of numberless atoms into the world, to establish the universal and conspiring harmony of things; and especially to connect those atoms into such various seminal textures, upon which most of the more abstruse operations, and elaborate productions of nature appear to depend. For many things may be performed by matter variously figured and moved, which yet would never be performed by it, if it had been still left to it self without being, at first at least, fashioned after such a manner, and put into such a motion by an intelligent agent. As the quill, that a philosopher writes with, being dipt in ink, and then moved after such and such a manner upon white paper, all which are corporeal things, or their motions, may very well trace an excellent and rational discourse; but the quill would never have been moved after the requisite manner upon the paper, had not its motion been guided and regulated by the understanding of the writer. Or rather, yet once more, to resume our former example of the *Strafburg*-clock; though a skilful artist, admitted to examine and consider it, both without and within, may very well discern, that such wheels, springs, weights, and other pieces, of which the engine consists, being set together in such a coaptation, are sufficient to produce such and such motions, and such other effects as that clock is celebrated for; yet the more he discerns the aptness and sufficiency of the parts to produce the effects emergent from them, the less he will be apt to suspect, that so curious an engine was produced by any casual concurrence of the parts it consists of, and not rather by the skill of an intelligent and ingenious contriver; or that the wheels, and other parts, were of this or that size, or this or that determinate shape, for any other reason, than because it pleased the artificer to make them so: though the reason, that moved the artificer to employ such figures and quantities sooner than others, may well be supposed to have been, that the nature of his design made him think it very proper and commodious for its accomplishment, if not better than any other suited to the several exigencies of it.

IF an Epicurean should be told, that a man, after having been for some days really dead, became alive again, I think it will not be doubted, but that he would reject such a relation as impossible, and therefore too manifestly false to be believed by any man in his wits: and yet, according to his principles, the man, as well soul as body, consisted only of divers particles of the universal matter, by various motions brought together, and disposed after a certain manner: and consequently, he must ground his persuasion, that it is impossible to redintegrate the engine once spoiled by death, upon this, that as chance cannot with the least probability be presumed to have produced such a strange effect; so, according to him, there can be no cause assigned, knowing and powerful enough to rally and bring together again the disbanded and scattered parcels of matter (or substitute other equivalent ones) that, together with the remaining carcass, composed the dead man, so to re-unite them to the rest; and lastly, so to place and put into motion both the one and the other, as were requisite to make a living man once more result from them. I know, that this example reaches not all the circumstances of the controversy

controversy we have been debating; but yet, if I mistake not, it will serve the turn, for which I propose it. For, not now to insist upon this inference from it, That a considering man may confidently reject a thing, that is not absolutely impossible, provided it be highly incredible; not to insist on this, I say, the thing I aim at in the mention of it, is only to shew, that such things may possibly be effected by matter and motion, as no wise man will believe to have been produced by a bare agitation of the particles of matter, not guided by the superintendency of a powerful and knowing Director.

Now that the atoms, or particles of matter, of which the world consists, made no agreement with each other to convene and settle in the manner requisite to constitute the universe, *Lucretius* does not so properly confess, as affirm, in that fore-cited passage, where he judiciously tells us, that

—*Certe neque consiliis primordia rerum
Ordine se quæque, atque sagaci mente locarunt :
Nec quos quæque darent motus pepigere profecto.*

AND the thing it self is manifest enough, from the nature of atoms confessedly inanimate and devoid of understanding.

So that although we should grant, *Pyrophilus*, the possible emergency of the innumerable effects we admire in the world, from the various properties and coalitions of atoms, yet still you see the formerly mentioned difficulty (touching the resulting of all things from matter left to it self) would recur; and it would as well be incredible, that an innumerable multitude of insensible particles, as that a lesser number of bigger parcels of matter, should either conspire to constitute, or fortuitously jumble themselves into so admirable and harmonious a fabrick as the universe, or as the body of man; and consequently it is not credible, that they should constitute either, unless as their motions were (at least, in order to their seminal contextures and primary coalitions) regulated and guided by an intelligent contriver and orderer of things. And I should so little think it a disparagement to have but so much said of any hypothesis of mine, that I suppose I may affirm it, without offending either the most sober, or the generality of the atomical philosophers, to whom, and to their doctrine, my writings will manifest to be no otherwise affected than I ought.

ESSAY V.

Wherein the Discourse, interrupted by the late Digression, is resumed and concluded.

IT remains now, *Pyrophilus*, that we at length return into the way from whence the foregoing digression has, I fear, too long diverted us; and that to prosecute and finish our discourse, we take it up where we left it, and were tempted to digress; namely, at the third essay; betwixt which, and the beginning of this fifth, all that has been interposed may be looked upon but as a long parenthesis.

IN the third place then I consider, that whether or no it be true, which our antagonists suggest, that there are some things in nature, which tempt philosophers more than they do the vulgar, to doubt or deny a God; yet certainly there are divers things

That there are some things in nature, which conduce much to the evincing of a Deity, which are only well known to naturalists.

Explained by the comparison of the uniting scattered pieces of paint into one face by a cylindrical looking glass.

The testimony of the author of the book *de Mundo*, ascribed to *Aristotle*, introduced.

Arist. de Mundo, cap. 6.

Ibidem.

in nature, that do much conduce to the evincing of a Deity, which naturalists either alone discern, or at least discern them better than other men. For besides the abstruse properties of particular bodies, not discovered by any but those, that make particular inquiries into those bodies, there are many things in nature, which to a superficial observer seem to have no relation to one another; whereas to a knowing naturalist, that is able to discern their secret correspondencies and alliances, these things, which seem to be altogether irrelative each to other, appear so proportionate and so harmonious both betwixt themselves, and in reference to the universe they are parts of, that they represent to him a very differing and incomparably better prospect than to another man: as he, that looks upon a picture made up of scattered and deformed pieces, beholding them united into one face by a cylindrical looking glass aptly placed, discerns the skill of the artist, that drew it, better than he, that looks only on the single parts of that picture, or upon the whole picture, without the uniting cylinder. Which brings into my mind, that whereas in the sacred story of the creation, when mention is made of God's having considered the works of each of the first six days, at the end of it, it is said of the work of every day, *That God saw, that it was good*, (except of the second day, because the separation of the waters was but imperfectly made on that day, and compleated in the next, on which it is therefore twice said, *That God saw, that it was good*;) whereas, I say, when God looked upon his works in particular, it is only said, *That he saw, that they were good*: when he is introduced at the close of the creation, as looking upon, and surveying his creatures in their harmony, and entire system, it is emphatically said, *That he saw every thing, that he had made, and behold it was very good*. And if *Aristotle* be indeed the author of the book *De Mundo ad Alexandrum*, which passes for his, and is said to have been written by him towards the end of his life, it would not be unworthy our observation to take notice, how he, that in his other writings is wont to talk of God's interest in the creatures darkly, and hesitantly enough, is wrought upon by the contemplation of the universe, as it is an orderly aggregate or system of the works of nature, to make expressions of the divine architect, which are not unworthy of *Aristotle*, though, being merely human, they cannot be worthy of God. Amongst many, I shall single out some; and I hope, *Pyrophilus*, you will excuse me, if in this essay, and some of the precedent ones, I do, contrary to my custom, employ pretty store of passages taken out of other authors. For first, the nature of my design makes it requisite for me to shew, what opinion the heathen philosophers had of the study of physiology, and what power their contemplation of nature had to ingage them to acts of religion. And next, since divers of the same passages, wherein they had set down their opinions, contained also the grounds and reasons of them, whereby they have anticipated much of what we should say upon the same subjects; I was unwilling to deprive you of their pertinent ratiocinations, or rob them of the glory of what they had well written. And this necessary apology premised, let us proceed to consider his passages; and first, *Restat* (says he) *ut summam de causa differamus, quæ cunctarum ipsa rerum vim habet tutricem & continentem, quemadmodum cætera perstrinximus: flagitii enim instar esset, cum de mundo dicere instituerim, tractatu si minus exquisito fortasse, at certè qui sat esse possit ad formulam doctrinæ crassiorẽ, intactam præcipuam mundi partem principemque præterire.* 'It remains, that we speak briefly concerning that cause, whose power preserves and supports all things, in like manner, as we have compendiously handled other matters. For it would seem criminal to pass over the chief part of the world untouched, having designed to discourse of the universe in a treatise, which, if less accurate, yet certainly may be sufficient for a rough platform of doctrine.' And a little after, *Etenim* (says he) *cunctarum quæ rerum natura complectitur, cum servator est Deus, tum vero quæcunque in hoc mundo quoquomodo perficiuntur, eorum omnium idem est genitor:*

genitor: non sic tamen ipse ut opificis in morem, animalisque lassitudinem sentientis labore affici possit, ut qui ea facultate utatur, quæ nulli cedat difficultati, cujus ipse vi facultatis omnia in potestate continet, nec minus etiam quæ longius ab ipso videntur esse summota: 'For God is both the preserver of all things contained in the universe, and likewise the producer of every thing whatsoever, which is in any wise made in this world: yet not so as to be sensible of labour; after the manner of a workman, or a creature, which is subject to weariness: for he is endued with a power, which is inferior to no difficulty, and whereby he contains all things under his authority, even such as seem most distant from him.'

Eodem Cap.

To which purpose he elsewhere says, *Augustinus* decentiusque existimandum est, Deum summo in loco ita esse collocatum; numinis ut tamen ejus vis per universum mundum pertingens, tum solem, lunamque moveat, tum cælum omne circumagat, simulque causam præbeat eorum, quæ in terra sunt salutis atque incolumitatis: 'It is more magnificent and agreeable to conceive God so resident in the highest place, that nevertheless his divine energy being diffused throughout the whole world, moves both the sun and moon, turns round the whole globe of heaven, and affords the causes of safety and preservation of such things as are upon the earth.'

Eodem Cap.

And in the same book he adds, *Ut vero summam loquamur, quod in navi gubernator est, quod in curru agitator, quod in choro præcentor, quod denique lex in civitate, & dux in exercitu, hoc Deus est in mundo. Nisi si hæcenus interest quod labor, & motus multiplex illos exercet & curæ angunt variæ, cum huic illaborata succedunt omnia, omnis molestiæ expertia:* 'But to sum up all in brief; what the pilot is in a ship, what the driver in a chariot, what the chief finger is in a dance; finally, what magistracy is in a commonwealth, and the general in an army, that is God in the world: unless there be this difference, that much toil and manifold cares perplex them, but all things are performed by God without labour or trouble.'

And certainly he, that is a stranger to anatomy, shall never be able to discern in the circulation of the blood, the motion of the chyle, and the contrivance of all the parts of a human body, those proofs, as well as effects, of an omniscient *Διούργος*, or artist, which a curious anatomist will discover in that elaborate and matchless engine: as I remember, I had occasion not long since to take notice of in the shape of that strange muscle (the *obturator internus*) which some call from its figure *marfupialis*, serving to the motion of the thigh. For this muscle seems so made, as if nature had designed in it to manifest, that she is skilled in the mechanicks, not only as a mathematician, that understands the powers of distance, weight, proportion, motion and figure; but as an artificer, or handicrafts man, who knows by dextrous contrivances to furnish the more endangered parts of his work, with what is more useful to make it lasting; there being (to omit other observables, belonging to that muscle) a deep notch made in the coxendix, to shorten the way betwixt the two extremities of the muscle, and make it bear upon the bone with a blunter angle. And because the tendon is long, left, notwithstanding the former provision, it should be apt to fret out upon the edge of the bone, nature has provided for it a musculous piece of flesh, wherein it is as it were sheathed, that so it might not immediately bear, and grate upon the bone; just as our artificers use to sew cases of leather upon those parts of filken strings, which being to grate upon harder bodies, were otherwise endangered to be fretted out by attrition.

Of the admirable contrivance of the make of the musculus marfupialis.

And a like skilfulness of nature in the mechanical contrivance of the parts, is more obviously discernible in the structure of that admirable engine, by which such variety of other engines are made, the hand: where (not to mention the *ligamentum latum*, or wrist-band, that keeps the tendons, that move under it, from inconveniently starting up upon the contraction of the respective muscles) the wonderful perforations, that are made through the tendons of the *musculi perforati* by those of the *musculi perforantes*, for the more commodious motion of the joints of the fingers, may conspicuously manifest

And of the parts of the hand.

The contrivance for the circulation of the blood in a fetus before the use of respiration.

the mechanical dexterity of nature; as it may her husbanding (if I may so speak) of her work, that in a fetus, whilst it lies in the womb, because the lungs are not to be displayed as afterwards, and so the blood needs not circulate thorough them, from the right ventricle of the heart into the left, for the use of respiration; as it must in grown animals, she contrives a nearer way; and by certain short pipes, peculiar to such young creatures, she more commodiously performs in them the circulation of the blood, proportioned to their present condition; and afterwards, when the animal is brought out of the womb into the open air, and put upon the constant exercise of his lungs, these temporary conduit-pipes, little by little, vanish. So careful is nature not to do things in vain.

Galen's speech, that his books de Usu Partium were as hymns to the Creator. Galenus lib. 30. De Usu Partium. The fabrick of the eye considered.

Some experimental observations of the eye, and use of its parts in order to vision.

The way to prepare the eyes of animals for the better making observations on them.

Some particulars wherein the eyes of white rabbits are better than others for observation.

AND therefore I do not much wonder, that *Galen*, though I remember he somewhere (unprovokedly and causelessly enough) derides *Moses*, and seems not over-much inclined to make religious acknowledgements; yet when he comes to consider particularly the exquisite structure of a human body, should break forth into very elevated, and even pathetical celebrations of God, and tell us, that in his books, *De Usu Partium*, he composed hymns to the Creator's praise. And certainly he, that shall see a skilful anatomist dextrously dissect that admirable part of man, the eye, and shall consider the curious contrivance of the several coats, humors, and other parts it consists of, with all their adaptations and uses, would be easily persuaded, that a good anatomist has much stronger invitations to believe, and admire an omniscient Author of nature, than he, that never saw a dissection; especially if he should see how all of these concur to make up one optical instrument, to convey the species of the visible object to the optick nerve, and so to the brain; as I have with pleasure considered it, in the recent eye of a cat (for with keeping it will grow flaccid) cut cleanly off, where the optick nerve enters the sclerotic, and is going to expand itself into the retina; for holding this eye at a convenient distance betwixt yours and a candle, you may see the image of a flame lively expressed upon that part of the back side of the eye, at which the optick nerve enters the above mentioned sclerotic. Something of this kind we have also shown our friends with eyes of dead men, carefully sever'd from their heads; and with the (dexterously taken out) crystalline humour of a human eye, we have often read, as with a lens or magnifying glass. And to assist you in so pleasing a speculation, as that of the eye, we shall add, that by reason ox eyes are much larger, and easier to be had than human ones, we are wont to make much use of them, and to discern some things better in their coats, we immerse them for a little while in boiling water; and to be able to consider the form and bigness of the vitreous and crystalline humours, better than the fluidity of the one, and the softness of the other are wont to allow anatomists to do; we have sometimes, by a way hereafter to be set down, speedily frozen eyes, and thereby have turned the vitreous humour into very numerous and diaphanous films (as it were of ice, and the crystalline into a firm substance) but (which perhaps you will wonder at) not transparent. An eye thus frozen may be cut along that, which optical writers call the optical axis, and then it affords an instructive prospect, which we have not been able to obtain any other way. But because, notwithstanding this expedient in the eyes of men, and the generality of terrestrial animals, the opacousness of the sclerotic hinders the pictures, that outward objects (unless they be lucid ones) make within the eye to be clearly discerned; we think our selves obliged to that excellent mathematician of your acquaintance, *Pyrophilus*, who, upon some discourse we had with him concerning this subject, lately advised us, to make use of the eyes of white rabbits (for if those animals be of another colour, he says, their eyes will not prove so fit for our purpose.) For having held some of these eyes at a convenient distance betwixt my eyes and the window, I found them to be so transparent, that the rays proceeding

ceeding from the panes of glass, iron bars, &c. of the window, passing through the crystalline humour and in their passage refracted, did on the retina, exhibit in an inverted posture, according to the optical laws, the contracted, but lively pictures of those external objects; and those pictures, by reason of the transparency of the sclerotis, became visible through it to my attentive eyes: as in a darkened room the shadows of objects without it, projected on a fine sheet of paper, may, by reason of the thinness of paper, be seen thorough it by those that stand behind it. By candle-light we could see little in the bottom of these eyes but lucid objects, such as the flame of the candle, which appeared tremulous, though inverted; but by day-light we could manifestly discern in them, both the motions of very neighbouring objects, and the more vivid of their colours.

AND really, *Pyrophilus*, it seems to me, not only highly dishonourable for a reasonable soul to live in so divinely built a mansion, as the body she resides in, altogether unacquainted with the exquisite structure of it; but I am confident, it is a great obstacle to our rendering God the praises due to him, for his having so excellently lodged us, that we are so ignorant of the curious workmanship of the mansions our souls live in: for not only the Psalmist, from the consideration of the divine art displayed by God, in the moulding and fashioning his body in the womb, takes a just occasion to celebrate his Maker, *I will praise thee* (says he) *because I am fearfully and wonderfully made. Marvellous are thy works, and that my soul knoweth right well: my substance was not hid from thee, when I was made in secret, and curiously wrought,* (with as much curiosity as tapestry or embroidery, as the Hebrew *Rukkamti* seems to import.) *In the lowest parts of the earth thine eyes did see my substance, yet being unperfect; and in thy book all my members were written, which in continuance were fashioned, when as yet there were none of them.* But even from *Galen* himself anatomical reflections have been able to extort expressions of devotion: *Cum igitur* (says he) *quod in omnibus recte fit, omnes ad artem referunt, quod autem in uno, aut duobus non ad artem, sed fortunam; merito ex nostri structura corporis licet admirari summam artem, æquitatem & vim naturæ quæ nos construxit. Constat siquidem corpus nostrum ex ossibus pluribus quam ducentis, ad singula ossa vero pervenit nutrienda vena; sicut ad musculos: cum hæc etiam arteria & nervi; parique adamussim sunt, & omnino similia in dextra animantis sita, iis quæ in altera sunt; os ossi, musculus musculo, vena venæ, arteria arteriæ, ac nervus nervo; idque exceptis visceribus, atque nonnullis particulis, quæ habere propriam descriptionem videntur. Duplices itaque corporis nostri partes, omnino inter se sunt similes & magnitudine & conformatione, sicuti & consistentia quam voco juxta molliem, duritiemque differentia. Quemadmodum igitur de humanis effectibus judicium faciamus, ex navi summa arte constructa cognoscentes peritiam artificis, ita etiam de Divinis facere convenit, corporisque nostri opificem admirari, quicumque tandem is deorum existat, etiamsi eum non videmus:* ‘Whereas therefore (saith he) all men ascribe that to art, which is made aright in all respects, but that, which is only in one or two, not to art, but fortune; the structure of our body gives us cause to admire the excellent art, exactness, and power of nature, which framed us. For our body consists of above two hundred bones; to each of which tends a vein for conveying of nourishment (in like manner as to the muscles) which is accompanied with an artery and a nerve; and the parts are exactly pairs, and those placed in the right side of an animal are wholly alike to those in the other, bone to bone, muscle to muscle, vein to vein, artery to artery, and nerve to nerve; excepting only the bowels, and some other parts, which seem to have a peculiar construction. So that the parts of our body are double, and altogether alike among themselves, both in greatness and shape, as also in consistence, which I place in the diversity of softness and hardness. As therefore we use to judge of things made by men, acknow-

That it is dishonourable for the soul to be unacquainted with the exquisite structure of the body, being its own mansion.

Psalm.
cxxxix.
14, 15, 16.

Proved out of instances in the Psalmist and *Galen*.

Galen de plac. Hip. & Plat.
lib. 7.

ledging

‘ledging the skill of a workman, by the building of a ship with extraordinary art;
 ‘so also it behoveth to do in those of God, and to admire the framer of our body,
 ‘whosoever of the gods he were, although we do not see him.’

PERHAPS it may be truly said yet further, that although in human bodies, many wonders, as we have lately mentioned, have been discovered to us by anatomy, yet anatomy it self has not discovered to us all the wonders to be met with in a human body, nor will detect them, till anatomists be skilled in some other things over and above that of dexterously dissecting. For it seems very probable, that the excellent contrivance of some parts will never be fully apprehended, without a competent knowledge of the nature of those juices, that are to pass thorough them, and some of them receive their beginning, or some alteration, in them; and the nature of these juices will scarce be exactly known, without some skill in divers parts of physiology, and especially in chymistry. Besides, the reason of the origination, shape, bulk, length, progress, and insertion of each particular muscle, can hardly be well accounted for without some skill in the principles of mechanicks, and in the nature and properties of leavers, pulleys, &c. Moreover, there is a certain harmonious proportion betwixt the parts of a human body, in reference both to the whole, and to one another, which is not wont to be heeded by anatomists, but much taken notice of by statuarios and painters. For they reckon, that when a man’s arms are displayed, the distance betwixt his middle fingers is equal to the height of his body; so they reckon sometimes seven, sometimes eight lengths of the head, to the length of the body; and four times the length of the nose to that of the head, as three times the same length to that of the face. And divers such observations we have met with among them, which we shall not now insist on, but rather tell you, that without some skill in opticks, it will be hard for an anatomist to shew the wisdom of God in making the crystalline humour of the eyes of men only of a somewhat convex or lenticular form, rather than as those of fishes of an almost perfectly spherical one, (as to the anterior part, which is obverted to the outward objects.) Nor do I remember, that in anatomy schools I have heard any account given of this difference, which yet tends much to manifest the wisdom of the author of nature, who has so excellently suited the eyes of animals to the several parts of the universe he designed them to inhabit. For men, and other terrestrial animals living in the air, the beams of light, reflected from visible objects, and falling over the cornea, and the aqueous humour, do necessarily suffer a refraction there, as coming from the air, which is a thinner medium, into a thicker, and so there needs the less of farther refraction to be made by the crystalline humour, and consequently its figure needs to be but moderately convex: whereas fishes living constantly in the water, the medium, through which they see things, is almost of a like thickness with the cornea and aqueous humour; so that there being little or no refraction made in their eyes but by the crystalline it self, it was necessary, that it should be exceedingly convex, that it might make a very great refraction, and thereby unite the beams nearer at hand; which, if the crystalline were less convex, would tend to a point of concourse beyond the retina, and consequently paint on it but a languid and confused picture of the object they should represent.

As for *Paracelsus*, certainly he is injurious to man, if (as some eminent chymists expound him) he calls man a microcosm, because his body is really made up of all the several kinds of creatures the macrocosm or greater world consists of, and so is but a model or epitome of the universe: for (to omit, that the ancients, as *Galen* informs us, gave the title of microcosms to animals in general) it is the glory and prerogative of man, that God was pleased to make him, not after the world’s image, but his own. On which occasion give me leave to tell you, that however the consideration

Why the
anterior
part of
fishes eyes
ought to be
more spher-
ical than
those of
men.

That God
made man
not after
the world’s
image, but
his own.

Lib. 3. De
Usu Part.

deration of the dignity conferred on us in the image of God, (in whatever that image be resolved to consist) should, methinks, be some engagement to us to look upon our selves as belonging unto God; as our Saviour, from the image of *Cæsar* stampt upon a coin, pronounced it fit to render unto *Cæsar* the things of *Cæsar*, and to God those of God.

That the image of God on us should engage us to esteem ourselves as belonging to God.

In the fourth place, I consider, that the universal experience of all ages manifests, that the contemplation of the world has been much more prevalent to make those, that have addicted themselves to it, believers, than deniers of a Deity. For it is very apparent, that the old philosophers, for the most part, acknowledged a God; and as evident it is, by their want of revelation, by many passages in their writings, and by divers other things not now to be insisted on, that the consideration of the works of nature was the chief thing, that induced them to acknowledge a divine author of them. This truth I could easily make out, were I at leisure to transcribe testimonies, which, because I am not, I shall content my self to mention to you one, which may well serve for many, it being a confession made by *Aristotle*, or whatever other learned philosopher it was, who writ the book *de Mundo*, that God's being the architect and upholder of the world was the general belief of the ages, that preceded his. *Vetus* (says he) *sermo est à majoribus proditus, inter omnes homines, universa tum ex Deo tum per Deum constituta fuisse atque coagmentata, nullamque naturam satis instructam ad salutem esse posse, quæ citra Dei præsidium, suæ ipsa demum tutelæ permessa sit*: 'It is an ancient tradition (saith he) diffused amongst all mankind from our ancestors, that all things were made and produced of God, and by God; and that no nature can be sufficiently furnished for its own safety, which is left without the support of God, to its own protection.' And as for both the opinion of that eminent author himself, and the grounds of it, he speaks of God and the creation almost in the terms of *St. Paul*: *Proinde* (says he) *hæc etiam de Deo sentienda nobis sunt, illo quidem, si vim species, valentissimo; si decorem, formosissimo; si vitam, immortali; denique, si virtutem, præstantissimo. Quapropter cum sit inconspicibilis naturæ omni interituræ, ipsis nihilominus ipse cernitur ab operibus, atque ea quidem quæ aëre quoquo modo affecto, quæ in terra, quæ in aqua, ea certè Dei opera esse meritò dixerimus: Dei inquam opera, cum imperio summo mundum, ac potestate obtinentis, ex quo Deo, ut inquit Empedocles physicus*:

Arguments from authority, and the experience of all ages, that the contemplation of the world has addicted man to the reverence of God.

Libro De Mundo, cap. 6.

Alibi eodem.

*Omnia quotquot erunt, quot sunt præsentia, quotque
Orta fuere antebac stirpes, hominesque feræque,
Indè etiam volucres, piscesque humoris alumni.*

'Thus therefore we ought to conceive of God: if we consider his power, he is omnipotent; if his shape, most beautiful; if his life, immortal; and finally, if his virtue, most excellent. Wherefore though undiscernable by any corruptible nature, yet he is perceived by such in his works; and indeed those things, which are produced in the air, by any mutation whatsoever, in the earth, or in the water, we ought deservedly to term the works of God; which God is the absolute and sovereign Lord of the world, and out of whom (as saith *Empedocles* the naturalist,)

*All things beginning have, which e'er shall be,
Are present or to come, plants, men, and beasts,
And fowl, and fish the off-spring of the sea.*

AND those few philosophers (if ever there have been any at all) that have been really atheists, are no ways considerable for their number, in respect of those, that have asserted a Deity; and their paradoxes have been looked upon as so irrational, that, as soon as they have been proposed, they have been disdainfully rejected and condemned

That those people, who worship not God, are not naturalists, but barbarians; and that their atheism doth continue for want of the contemplation of the world.
Psalm c. 3.
Judg. v. 20.

cap. 6.

A comparison of the image of God on the creature to that of *Pheidias* on *Minerva's* shield.

demned by all the rest of mankind, who have looked upon the patrons of them as monsters, rather than philosophers. And if there be, at this day, any nations (as navigators inform us there are in *Brasil*, and some other parts of the *Indies*) that worship no God, they consist not of naturalists, but brute, and irrational barbarians, who may be supposed rather to ignore the being of God, than deny it; and who, at least, are little less strangers to the mysteries of nature, than to the author of it. And if it be a truth, that there are really such atheistical people, it may serve to recommend to us the study of physiology, by shewing us, that without the help of any such innate belief, or persuasion of a God, as is supposed connatural to man, reason exercised upon the objects the creation presents us with, is sufficient to convince philosophers of a Deity. And indeed such a care has God taken, to make his being conspicuous in his creatures, that they all seem loudly and unanimously to speak to their attentive considerers, in the Psalmist's language, *Know ye, that the Lord he is God; it is he, that hath made us, and not we our selves.* And as it is said, *That the stars in their courses fought against Sisera*, so it may be truly said, that not only the stars, but all the rest of the creatures do in their courses fight against the atheist, by supplying an unprejudiced considerer of them with weapons fit to overthrow his impious error. To which purpose, I remember, *Aristotle*, in his book *de Mundo*, makes use of a pretty simile, to declare the conspicuousness of the Creator in his creatures: *Fama est* (says he) *Pheidiam illum statuarium, quum Minervam illam quæ est in arce coagmentaret, in medio ejus scuto faciem suam expressisse, oculosque fallenti artificio ita devinxisse simulachro, eximere ut inde ipsam siquis cuperet, minime posset, aliter quidem certè, quam ut ipsum solveret simulachrum, opusque ejusmodi compactile confunderet: hanc eandem rationem Deus habet in mundo, utpote qui universorum coagmentationem coherentem cokeneat & coarctet, incolumitatemque universitatis conservet; nisi quatenus non medio ille loco in terra scilicet, ubi turbida regio est, sed in excelso situs est, purus ipse in puro loco:* 'It is reported, that when *Pheidias*, the excellent statuary, made the image of *Minerva*, which is in the castle at *Athens*, he contrived his own picture in the middle of her shield, and fastened the eyes of it to the statue by so cunning workmanship, that if any one were minded to take it away, he could not do it without breaking the statue, and disordering the connection of the work. After the same manner is God in the world, retaining and upholding the coherence of all things, and preserving the safety of the universe: only he is not in the midst of it, namely the earth, which is a turbulent region; but in the highest place, which is suitable to his purity.'

BUT to declare, how atheists may be reduced either to confess a first cause, or to offer violence to their own faculties, by denying things as certain as those, which it is apparent that (in other cases) themselves firmly assent to, would require a discourse too large to be proper to be prosecuted here; and therefore if I have not, in another treatise, an opportunity of insisting on that subject, I must content my self to refer you, for further satisfaction on it, to the writers of natural theology.

NOR does physiology barely conduce to make men believe the existence of a Deity, but admire and celebrate the perfections of it: and the noblest worship from that greater part of the world, to which God did not vouchsafe any explicate and particular revelation of his will, hath been paid him by those, whom the beauty of this goodly temple of the universe transported with a rational wonder at the wisdom, power, and goodness of the divine architect. And this kind of devotion being commonly proportionate to the discoveries of nature, that begot it, it needs not seem strange, that divers of the best philosophers amongst the Heathens should be the greatest celebrators of God. And it was therefore, perhaps, not without cause, that the Indian gymnosophists, the Persian magi, the Egyptian sacrificers, and the old Gauls druids, were to their people both

both philosophers and priests; and that in divers civilized nations, philosophy and priesthood were so allied, that those whose profession should give them most interest in the definition of man, made a more strict profession of celebrating and praising God. I might easily, with divers instances, manifest, how great a veneration the study of the creatures has given philosophers, for those attributes of God, that are stamp'd upon them, and conspicuous in them: but my willingness to hasten to the more experimental part of what I have to say concerning the usefulness of physiology, makes me content my self to present you with a couple, or a leash of authorities, for proof of what has been alledged: the first shall be of *Galen*, in his third book *De usu partium*, where treating of the skin, that invests the sole of the foot, *Cutem ipsam* (says he) *non laxam, aut subtilem, aut mollem, sed constrictam, & mediocriter duram, sensilemque ut non facile pateretur, subdidit pedi sapientissimus Conditor noster: cui commentarios hos, ceu hymnos quosdam compono, & in eo pietatem esse existimans, non si taurorum ἐκατόμβας ei plurimas quispiam sacrificarit, & casias aliaque sexcenta unguenta suffumigarit. Sed si noverim ipse primus, deinde exposuerim aliis, quanam sit ipse sapientia, quæ virtus, quæ providentia, quæ bonitas; ignorantia quorum summa impietas est, non si à sacrificio abstineas. Quod enim cultu convenienti exornavit omnia, nullique bona inviderit id perfectissimæ bonitatis specimen esse statuo. Invenisse autem quo pacto omnia adornarentur summæ sapientiæ est, at effecisse omnia quæ voluit virtutis est invictæ.* ‘Our most wise Creator hath placed under the foot a skin, not loose, or thin, or soft, but close, and of indifferent hardness and sense, to the end it might not easily suffer injury. To him I compose these commentaries as certain hymns, esteeming piety not to consist in sacrificing many hecatombs of oxen to him, or burning cassia, and a thousand other perfumes; but in this, first to know my self, and then to declare to others, what his wisdom, power, providence, and goodness is: the ignorance of which, not the abstaining from sacrifice, is the greatest impiety. For I account it an evidence of most perfect goodness, that he hath furnished all things with convenient ornament, and denied his benefits to none. Now to have devised, how all things might be handsomely framed, is the part of highest wisdom; but to have made all things, which he would, of insuperable power.’ To which illustrious passage he annexes much more, worthy of *Galen’s* pen, and your perusal.

The noblest worship, that has been paid God, from such, who have not had particular revelation of his will, has arose from the speculation of God’s wisdom, power, and goodness in the fabricke of the creatures.

To this let me add, in the second place, that of *Hermes Trismegistus*, almost at the very beginning of his first book, Englished by Dr. Everard: *He that shall learn and study the things that are, and how they are ordered and governed, and by whom, and for what cause, or to what end, will acknowledge thanks to the workman, as to a good father, an excellent nurse, and a faithful steward; and he that gives thanks shall be pious or religious, and he that is religious shall know both where the truth is, and what it is; and learning that, he will be yet more and more religious.* To which I cannot but add, a resembling passage of that great Hermetical philosopher (as his followers love to call him) *Paracelsus*: *Oppido* (says he) *admirabilis, in suis operibus, Deus est; à quorum contemplatione nec interdiu, nec noctu desistendum, sed jugiter illorum indagationi vacandum est, hoc enim est ambulare in viis Dei:* ‘God is very admirable in his works; from the contemplation of which we ought not to desist night or day, but continually be employed in the inquisition of them: for this is to walk in the ways of God.’ All which bears witness to, and may, in exchange, receive authority from that remarkable passage of that great and solid philosopher, Sir Francis Bacon, who scruples not somewhere to affirm, ‘That a little or superficial taste of philosophy, may, perchance, incline the mind of a man to atheism; but a full draught thereof brings the mind back again to religion. For in the entrance of philosophy, when the second causes, which are next unto the senses, do offer themselves to the mind of man, and the mind itself cleaves unto them, and dwells there, a forgetfulness of the highest cause may creep in: but when a man passeth further, and beholds the dependency, continuation, and confeder-

The testimonies of *Galen*, *Hermes*, *Paracelsus*, *L. Bacon*.

Paracel. de Mineral. Tract. I.

Sir Francis Bacon Advancem. of Learning, lib. I.

Gen. xxviii.

‘racy of causes, and the works of providence, then, according to the allegory of the poets, he will easily believe, that the highest link of nature’s chain must needs be tied to the foot of *Jupiter’s* chair:’ or (to speak our chancellor’s thoughts more scripturally) ‘That physiology, like *Jacob’s* vision, discovers to us a ladder, whose top reaches up to the foot-stool of the throne of God.’ To which he deservedly adds; *Let no man, upon a weak conceit of sobriety, or ill-applied moderation, think or maintain, that a man can search too far, or be too well studied, in the book of God’s word, or in the book of God’s works, divinity, or philosophy. But rather let men awake themselves, and cheerfully endeavour and pursue an endless progress or proficiency in both; only let them beware lest they apply knowledge to swelling, not to charity, to ostentation, not to use: And again, that they do not unwisely mingle and confound these distinct learnings of theology and philosophy, and their several waters together.*

That religion has other arguments besides those drawn from the works of nature, enough to keep any considering man from atheism.

Jam. ii. 19.

IN the fifth place, *Pyrophilus*, I consider, that when the divines we are answering, suppose physiology likely to render a man an atheist, they do it (as hath above been noted already) upon this ground, that natural philosophy may enable him to explicate both the regular phenomena, and the aberrations of nature, without having recourse to a first cause or God. But though this supposal were as great a truth, as we have endeavoured to make it a mistake, yet I see not, why a studier of physiology, though ever so great a proficient in it, may not rationally be an utter enemy to atheism. For the contemplation of the creatures is but one of the ways of coming to be convinced, that there is a God; and therefore, though religion were unable to make use of the argument drawn from the works of nature, to prove the existence of a Deity, yet has she other arguments enough besides, to keep any considerate and impartial man from growing an atheist. And here give me leave, for the sake of these divines, to observe that though the devils be spirits, not only extremely knowing in the properties of things, (by their hidden skill in physiology, by which they teach magicians, and their other clients, to do divers of the strange things for which they are admired) but also unmeasurably proud, and willing to pervert their knowledge to the cherishing of atheism, yet *St. James* informs us, *that they themselves believe there is a God, and tremble at him:* which argues, either, that skill in natural philosophy does not necessarily lead to atheism, or that there are other arguments, besides those drawn from science, sufficient to convince the most refractory of the existence of a Deity.

BUT not to insist on any thing of this nature, nor so much as to mention, what proofs the consideration of our own minds, and their in-bred notions may afford us of a Deity, I shall content myself to mind you, that the several patefactions, which God has been pleased to make of himself, to man especially, those made by seasonably accomplished prophecies, and by miracles, do not only demonstrate the being, but the providence, and divers of the attributes of God. And indeed, methinks, the divines we reason with, may well allow these patefactions to be capable of evincing the existence of a God, since they are sufficient, and, for aught I know, the best arguments we have to convince a rational man of the truth of the Christian religion. For the miracles of *Christ* (especially his resurrection) and those of his disciples, by being works altogether supernatural, overthrow atheism; and being owned to be done in God’s name, and to authorize a doctrine ascribed to his inspiration, his goodness and his wisdom, permit us not to believe, that he would suffer such numerous, great, and uncontrolled miracles, to be set as his seals to a lye, and delude men little less than inevitably into the belief of a doctrine not true. And as for the miracles themselves (especially that of *Christ’s* resurrection, so much, and so deservedly insisted on by *Peter* to the Jews, and *Paul* to the Gentiles) the truth of them is so ascertained to us by many of the solemnest, and most authentick ways of attestation, whereby the certainty of matters of fact is capable of being satisfactorily made out, that it is hard to shew how these testimonies can be denied, without denying some acknowledged

ledged principle of reason, or some other received notion, which these contradictors opinions or practice manifest them to look upon as a truth. And upon this account, so much might be said to evince the reasonableness of assenting to the Christian religion, and to shew, that as much may be said for it, as need be said for any religion, and much more, than can be said for any other; that it need be no wonder, that, as learned men as ever the world admired, have not only been many of them embracers, but some of them champions of it. But having more fully, in another treatise, discoursed of this subject, I shall content my self to make this inference from what has been alledged, that since the most judicious propugners of Christianity have held and found, that, upon the score of God's miraculous revelations of himself, rational men might be brought to believe the abstruse articles of the Christian religion, those revelations cannot but be sufficient to convince them of so fundamental and refulgent a truth (which all the others suppose) as that of the existence of God.

IN the sixth and last place, I will here add (on this occasion) that an insight into physiological principles may very much assist a man to answer the objections of atheists against the being of a Deity, and the exceptions they make to the arguments brought to prove, that there is one. For though it has long been the custom of such men, to talk, as if themselves, and those of their mind, were not alone the best, but almost the only naturalists; and to perplex others with pretending, that, whereas it is not conceivable, how there can be a God; all things are by the principles of the atomical philosophy, made clear and facil: Though this, I say, have long been used among the opposers of a Deity, yet he, that, not regarding their confidence, shall attentively consider the very first principles of things, may plainly enough discern, that of the arguments, wherewith natural philosophy has furnished atheists, those, that are indeed considerable, are far fewer than one would readily think; and that the difficulty of conceiving the eternity, self-existence, and some other attributes of God (though that afford them their grand objection) proceeds not so much from any absurdity belonging to the notion of a Deity, as such; as from the difficulty, which our dim human intellects find to conceive the nature of those first things (whatever we suppose them) which, to be the causes of all others, must be themselves without cause: for he, that shall attentively consider, what the atomists themselves may be compelled to allow, concerning the eternity of matter, the origin of local motion (which plainly belongs not to the nature of body) the infinity or boundlessness of space, the divisibleness or non-divisibility of each corporeal substance into infinite material parts, may clearly perceive, that the atomist, by denying, that there is a God, cannot free his understanding from such puzzling difficulties, as he pretends to be the reasons of his denial: for instead of one God, he must confess an infinite number of atoms to be eternal, self-existent, immortal, self-moving, and must make suppositions, incumbered with difficulties enough to him, that has competently accustomed his thoughts to leave second causes, beneath them, and contemplate those causes, that have none. But I am unwilling to swell this essay, by insisting on such considerations as these, especially since you may find them more aptly deduced in other papers, some of which treat of the truth of Christian religion, and others are designed for the illustration of some things in this and the foregoing essays. For I must confess to you, *Pyrophilus*, that by reason of sundry avocations, I have been so diverted from proposing some of the reasons I have employed to their best advantage, that I my self, at another time, could have both mentioned them with lesser disadvantage, and have added divers others: and therefore, I have not only had thoughts of enlarging upon some passages of our past discourse, but I long since made a collection (though it be not now in my power) of observations, and experiments to elucidate a point in one of those discourses, whereby may be enervated one of the three chief physiological reasonings, that I have met with, among the atheists.

That the difficulty of conceiving the eternity, self-existence, and other attributes of one God, is less, than to conceive infinite eternal self-existent and self-moving atoms.

UPON consideration of all the premises, I confess, *Pyrophilus*, that I am inclined to think there may, perhaps, be more cause to apprehend, that the delightfulness of the study of physiology should too much confine your thoughts and joys to the creatures, than that your proficiency in it should bring you to disbelieve the Creator. For I have observed it to be a fault, incident enough to ingenious persons, to let their minds be so taken up, and, as it were, charmed with that almost infinite variety of pleasing objects, which nature presents to their contemplation, that they too much dis-relish other pleasures and employments, and are too apt to undervalue even those, wherewith the improved opportunities of serving God, or holding communion with him, are capable of blessing the pious soul.

As God is infinitely better than all his creatures, so the knowledge of him is better than the knowledge of his creatures.

BUT, *Pyrophilus*, though comparatively to fame, and mistresses, and bags, and bottles, and those other transient, unsatisfactory, (in a word) deluding objects, on which the greatest part of mistaken mortals so fondly doat, the entertaining of our noblest faculties with objects suited to them, and proper both to gratify our curiosity, and to enrich our understandings, with variety of acceptable and useful notions, affords a satisfaction, that very well deserves the choice and preference of a rational creature; yet certainly, *Pyrophilus*, as God is infinitely better than all the things, that he has made, so the knowledge of him is much better than the knowledge of them: and he, that has placed so much delightfulness in a knowledge, wherein he allows his very enemies to become very great proficient, has sure reserved much higher, and more contenting pleasures to sweeten and endear those disclosures of himself, which he vouchsafes to none but those that love him, and are loved by him.

The imperfection and disquiet, that there is in human science.
Eccles. i. 13.

Eccles. i. 18.

2 Kings cap. ii.

AND therefore, *Pyrophilus*, though I will allow you to expect from the contemplation of nature a greater satisfaction, than from any thing you need decline for it, yet I would not have you expect from it any such satisfaction as you may entirely acquiesce in; for nothing but the enjoyment of him, that made the soul for himself, can satisfy it, the creatures being as well incapable to afford us a complete felicity by our intellectual speculations of them, as by our sensual fruitions of them. For though the knowledge of nature be preferable by odds to those other idols, which we have mentioned, as inferiour to it, yet we here attain that knowledge but very imperfectly, and our acquisitions of it cost us so dear, and the pleasure of them is so allayed with the disquieting curiosity they are wont to excite, that the wisest of men, and greatest of philosophers among the ancients, scruples not, upon his own experience, to call the ad-dicting of *one's heart to seek and search out by wisdom, concerning all things that are done under the heaven, a sore travel given by God to the sons of men; to be exercised* (or, as the original hath it, *to afflict themselves*) *therewith*. And the same experienced writer elsewhere tells us, *That he that increases knowledge, increases sorrow*. And it was perhaps for this reason, that *Adam* was formed out of paradise, and afterwards by God brought into it, to intimate, that felicity is not a thing, that man can acquire for himself, but must receive as a free gift from the liberal hand of God. And as the children of the prophets sought translated *Elias* with very great diligence, but with no success, so do we, as fruitlessly as industriously, seek after perfect happiness here, both they and we missing of what we seek, for the same reason; because we seek for that on earth, which is not to be found but in heaven. And this I forewarn you of, *Pyrophilus*, not at all to discourage you from the study of physiology, but to keep you from meeting with that great discouragement of finding in it much less of satisfaction than you expected; an over-great expectation from it being one of the disadvantageous circumstances with which it is possible for any thing to be enjoyed.

BUT at length, *Pyrophilus*, though late, I begin to discern, into how tedious a digression my zeal for natural philosophy, and for you, has mis-led me, and how it has drawn from my pen some passages, which may seem to relish more of the preacher, than

than the naturalist; yet I might alledge divers things to justify, or, at least, extenuate what I have done: as first, that if in making this excursion I have erred, I have not done so without the authority of great examples. For not only *Seneca* doth frequently both season his natural speculations with moral documents and reflexions, and owns, that he purposely does so, where he says, *Omnibus rebus, omnibusque sermonibus aliquid salutare miscendum est, cum imus per occulta naturæ, &c.* But even *Pliny* (as far as he was from being guilty of over-much devotion) does, from divers passages in his Natural History, allow himself to take occasion to inveigh against the luxury, excesses, and other epidemical vices of his time. And I might next represent, that perhaps the endeavouring to manifest, that the knowledge of the creatures should, and how it may be referred to the Creator's glory, is not altogether impertinent to the design I have of promoting physiology; for it seems consonant both to God's goodness, and that repeated axiom in the gospel, which tells us, *that he, that improves his talents to good uses, shall be intrusted with more*; that the imploying the little knowledge I have in the service of him I owe it to, may invite him to increase that little, and make it less despicable. And perhaps it is not the least cause of our ignorance, in natural philosophy itself, that when we study the great book of nature, called the Universe, we consult, peradventure, almost all other expositors to understand its mysteries, without making any address for instruction to the author, who yet is justly styled in the Scripture, *that Father of lights* (in the plural number) *from whom descends every good and every perfect gift*; not only those supernatural graces, that relate to another world, but those intellectual endowments, that qualify men for the prosperous contemplation of this: and therefore in the evangelical prophet, he is said to instruct even the plough-man, and teach him the skill and understanding he displays in his own profession. And though I dare not affirm, with some of the Helmontians and Paracelsians, that God discloses to men the great mystery of chymistry by good angels, or by nocturnal visions, as he once taught *Jacob*, to make lambs and kids come into the world speckled, and ring-streaked; yet persuaded I am, that the favour of God does (much more than most men are aware of) vouchsafe to promote some men's proficiency in the study of nature, partly by protecting their attempts from those unlucky accidents, which often make ingenuous and industrious endeavours miscarry; and partly by making them dear and acceptable to the possessors of secrets, by whose friendly communication they may often learn that in a few moments, which cost the imparters many a year's toil and study; and partly too, or rather principally, by directing them to those happy and pregnant hints, which an ordinary skill and industry may so improve, as to do such things, and make such discoveries by virtue of them, as both others, and the person himself, whose knowledge is thus increased, would scarce have imagined to be possible: and in effect, the chiefest of the secrets, that have been communicated to me, the owners have acknowledged to me to have been attained, rather, as they were pleased to speak, by accidental hints, than accurate inquiries: concessions of this nature I have divers times met with in the writings of the more ingenious of the chymists, and of other naturalists, and by one of these accidental hints, of late, the acute and lucky *Pecquet* was directed to find the newly discovered *lactæa thoracica*, as before him *Asellius* found without seeking, as himself confesseth, the *lactæa mesenterica*; and by an accident too (as himself hath told me) did our industrious anatomist, Dr. *Jolive*, first light upon those yet more freshly detected vessels, which afterwards the ingenious *Bartbolinus*, without being informed of them, or seeking for them, hath met with, and acquainted the world with, under the name of *vasa lymphatica*; and the two great inventions of the latter ages, gunpowder, and the loadstone's respect unto the poles, are supposed to be due rather to chance, than any extraordinary skill in philosophical principles (which indeed would scarce have made any man dream of such extravagant properties, as those of magnetick bodies) as if God designed.

Seneca Nat. quæst. lib. 2. cap. 59.

How the favour of God conduces to promote men's proficiency in the study of nature.

Jam. i. 17.

Isa. xxviii. 25, 26.

Gen. xxxi.

designed to keep philosophers humble, and (though he allow regular industry sufficient encouragement, yet) to remain himself dispenser of the chief mysteries of nature.

The reason
of the au-
thor's so
long dis-
course on
this subject.

To what hath been represented, *Pyrophilus*, I might add much more to excuse my excursions, if I were not content to be beholden to you for a pardon; and to invite you to grant it me, I shall promise you to be very careful not to repeat the like offence. And whereas most chymical writers take occasion, from almost every discovery or process they acquaint us with, to digress and wander into tedious, and too often dull and impertinent theological reflections or sermons; I have troubled you with almost all that I have to say (to you) of theological at once, and I have endeavoured to sprinkle it, as far as the subject would allow me, with some passages experimental. And indeed I should not at all have engaged my self into so long a discourse of the not only innocency, but usefulnesses of the knowledge of nature, in reference to religion, but that I could not acquiesce in what I had met with on that subject in any of the writers I have perused, divines being commonly too unacquainted with nature, to be able to manage it physiologically enough, and naturalists commonly esteeming it no part of their work to treat of it at all. And therefore I scruple not to confess freely to you, *Pyrophilus*, that, as I shall think my self richly rewarded for all the ensuing essays, if the past discourse but prove so happy as to bring you to value, and to make the religious use of the creatures recommended to you in it; so I had rather any of my papers should be passed by unperused, than those parts of these essays, that treat of that use. And indeed it is none of the least of satisfactions I hope to derive from my physical composures, that by premising before them the now almost finished discourse, I have done my hearty endeavour to manifest and recommend the true use of all the discoveries of nature, which either my inquiries, or your own, may afford you. And indeed for my part, *Pyrophilus*, I esteem the doctrine I have been pleading for of that importance, that I am persuaded, that he, that could bring philosophical devotion into the request it merits, would contribute as much to the solemnizing of God's praises, as the benefactors of choristers and founders of chauntries, and not much less than *David's* so celebrated designation and settlement of that religious Levitical musick, instituted for the solemn celebration of God.

Beasts in-
habit and
enjoy the
world, it is
man's duty
to spiritua-
lize it.

That it
being the
prime duty
of man to
give God
the honour
of his crea-
tures, it is
to be pre-
ferred be-
fore secon-
dary duties.

For the sensible representations of God's attributes to be met with in the creatures, occurring almost every where to our observation, would very assiduously solicit us to admire him, did we but arightly discern him in them; and the impressions made on the mind by these representations, proceeding not from a bare (and perhaps languid) whether belief or notion of the perfections expressed in them, but from an actual and operative intuition of them, would excite an admiration (with the devotion springing thence) by so much the more intense, by how much (it would be) more rational. And sure, *Pyrophilus*, so much admirable workmanship, as God hath displayed in the universe, was never meant for eyes that wilfully close themselves, and affront it with the not judging it worthy the speculating. Beasts inhabit and enjoy the world; man, if he will do more, must study, and (if I may so speak) spiritualize it. It is the first act of religion, and equally obliging in all religions: it is the duty of man, as man; and the homage we pay for the privilege of reason; which was given us, not only to refer our selves, but the other creatures; that want it, to the Creator's glory. Which makes me sometimes angry with them, who so busy themselves in the duties and employments of their second and superinduced relations, that they will never find the leisure to discharge that primitive and natural obligation, who are more concerned as citizens of any place, than of the world; and both worship God so barely as Catholick or Protestants, Anabaptists or Socinians, and live so wholly as lords or counsellors, Londoners or Parisians, that they will never find the leisure, or consider not, that it concerns them to worship and live as men.

And

And the neglect of this philosophical worship of God, for which we are pleading, seems to be culpable in men proportionably to their being qualified, and comply with that invitation of the Psalmist, *to sing praises to God with understanding*, or (the expression in the original being somewhat ambiguous) *to sing to him a learned canticle*, as he elsewhere speaks, *to praise him according to his excellent greatness*. For knowledge being a gift of God, intrusted to us to glorify the giver with it, the greatness of it must aggravate the neglect of imploying it gratefully; and the sublimest knowledge here attainable will not destroy, but only heighten and ennoble our admiration, and will prove the incense or more spiritual and acceptable part of that sacrifice of praise, (for those reflections, which their nature makes only acts of reason, their end may make acts of piety) wherein the intelligent admirer offers the whole world in eucharists to its Maker. For admiration (I do not say astonishment or surprize) being an acknowledgment of the objects transcending our knowledge, the learner the transcendent faculty is, the greater is the admired objects transcendence acknowledged. And certainly, God's wisdom is much less glorified by the vulgar astonishment of an unlettered starrer, (whose ignorance may be as well suspected for his wonder, as the excellency of the object) than from their learned hymns, whose industrious curiosity hath brought their understandings to a prostrate veneration of what their reason, not ignorance, hath taught them not to be perfectly comprehensible by them.

AND as such persons have such piercing eyes, that where a transient or unlearned glance scarce observes any thing, they can discern an adorable wisdom, being able (as I may so speak) to read the stenography of God's omniscient hand; so their skilful fingers know how to chuse and how to touch those strings, that may sound sweetest to the praise of their Maker. And on the opened body of the same animal, a skilful anatomist will make reflections, as much more to the honour of its Creator, than an ordinary butcher can; as the musick made on a lute, by a rare lutanist, will be preferable to the noise made on the same instrument by a stranger unto melody. And give me leave to tell you, *Pyrophilus*, that such a reasonable worship (*λογική λατρεία*) of God (to use St. Paul's expression, though in another sense) is perhaps a much nobler way of adoring him, than those, that are not qualified to practise it, are aware of, and is not improper even for Christians to exercise. For, *Pyrophilus*, it would be considered, that as God hath not, by becoming (as the Scripture more than once styles him) our Saviour, laid by his first relation to us as our Creator (whence St. Peter exhorts, even the suffering Christians of his time, to commit their souls to God under the notion of a faithful Creator) so neither hath he given up his right to those intelligent adorations from us, which become us upon the account of being his rational creatures: neither are such performances made less acceptable to him by the filial relation, into which Christ hath brought us to him; that glorious relation as well endearing to him our services, as our persons.

AND let me add, *Pyrophilus*, that not only *Galen* (as we have seen already) tells us, that the discerning one's self, and discovering to others the perfections of God displayed in the creatures, is a more acceptable act of religion, than the burning of sacrifices or perfumes upon his altars: and not only *Trismegistus*, forbidding *Asclepius* to burn incense, tells him, 'That the thanks and praises of men, are the noblest incense that can be offered up to God.' But God himself (in his written word) is pleased to say, *That he, that sacrificeth praise* (for so it is in the original) *honoureth him*. And the Scripture constantly mentions as a very acceptable part of religious worship, the *sacrifice of praise, and the calves of our lips*: by offering up of which, we make that true use of the creatures, of so referring them to their Creator's glory, that (to conclude this discourse by crowning it, as it were, with that excellent circle mentioned by the Apostle) as *all things are of him, and through him*, so they may be *to him; to whom be glory for ever, Amen*.

Psal. xlvii.
7.
Psal. cl. 2.

That the different greatness in the knowledge makes a like difference in the honour given to the Creator.
Rom. xii. 1.

1 Tim. i. 7.
Tit. ii. 10.

1 Pet. iv. 19.
God, by becoming our Saviour, has not laid aside the relation of a Creator.

That he, who sacrificeth praise, honoureth God.

Hermes Trism. in Asclep. c. 15.

The conclusion.
Heb. xiii. 15.

Rom. xi. 36.

OF THE
USEFULNESS
OF
NATURAL PHILOSOPHY.

PART II.

SECT. I.

Of its Usefulness to PHYSICK.

ESSAY I.

*Containing some particulars tending to shew the Usefulness of
NATURAL PHILOSOPHY to the Physiological Part of Physick.*

The advantage of the knowledge of nature towards the increasing the power of man; and its use as to health of the body and goods of fortune.

AFTER having, in the former part of this treatise, *Pyrophilus*, thus largely endeavoured to manifest to you the advantageousness of natural philosophy to the mind of man, we shall now proceed to speak of its usefulness both to his body and fortune. For I must ingenuously confess to you, *Pyrophilus*, that I should not have near so high a value as I now cherish for physiology, if I thought it could only teach a man to discourse of nature, but not at all to master her; and served only, with pleasing speculations to entertain his understanding, without at all increasing his power. And though I presume not to judge of other men's knowledge; yet, for my own particular, I shall not dare to think my self a true naturalist, till my skill can make my garden yield better herbs and flowers, or my orchard better fruit, or my field better corn, or my dairy better cheese, than theirs that are strangers to physiology. And certainly, *Pyrophilus*, if we seriously intend to convince the distrustful world of the real usefulness of natural philosophy, we must take some such course, as that Milesian *Thales* did, who was by the antients reckoned among the very first of their naturalists, and their seven celebrated wise men. Of this *Thales* it is reported, that being upbraidingly demanded, what advantage the professors of astrology could derive from the knowledge of it; he astrologically foreseeing what a year it would prove for olives, before any wonted signs of it did appear to husbandmen, ingrossed, by giving earnest, the greater part of the olives, which the next season should afford to *Chios* and *Miletus*; and being thereby enabled, when most men wanted oil, to sell his at his own rates, he made advantage enough of his skill, to let his friends see, that philosophers may have the acquisition of wealth more in their power than in their aim.

METHINKS, it should be a disparagement to a philosopher, when he descends to consider husbandry, not to be able, with all his science, to improve the precepts of an art, resulting from the lame and unlearned observations and practice of such illiterate persons as gardeners, plowmen, and milkmaids. And indeed, *Pyrophilus*, though it be
but

but too evident, that the barren philosophy, wont to be taught in the schools, hath hitherto been found of very little use in human life; yet if the true principles of that fertile science were thoroughly known, considered, and applied, it is scarce imaginable, how universal and advantageous a change they would make in the world. For in man's knowledge of the nature of the creatures, doth principally consist his empire over them, (his knowledge and his power having generally the same limits.) And as the nerves, that move the whole body, and by it, that great variety of engines employed by man on his manifold occasions, proceed from the brain; so all the operations, by which we alter nature, and produce such changes in the creatures, flow from our knowledge of them. Theological inquiries excepted, there is no employment, wherein mankind is so much and so generally concerned, as it is in the study of natural philosophy. And those great transactions, which make such a noise in the world, and establish monarchies or ruin empires, reach not so many persons with their influence, as do the theories of physiology.

That in man's knowledge of the nature of creatures, consists his empire over them.

To manifest this truth, we need but consider, what changes in the face of things have been made by two discoveries, trivial enough; the one being but of the inclination of the needle, touched by the loadstone, to point toward the pole; the other being but a casual discovery of the supposed antipathy between salt-petre, and brimstone: for without the knowledge of the former, those vast regions of *America*, and all the treasures of gold, silver, and precious stones, and much more precious simples they send us, would have probably continued undetected; and the latter giving an occasional rise to the invention of gunpowder, hath quite altered the condition of martial affairs over the world, both by sea and land. And certainly, true natural philosophy is so far from being a barren speculative knowledge, that physick, husbandry, and very many trades (as those of tanners, dyers, brewers, founders, &c.) are but corollaries or applications of some few theorems of it.

That the discovery of *America* is owed to the knowledge of the loadstone's polarity. That the martial affairs all over the world were altered by the knowledge of the nature of brimstone and salt-petre.

If I had not a great respect for the great *Hippocrates*, I should venture to say, that some of those rigid laws of *Draco* (whose severity made men say, that they were written in blood) have, perhaps, cost fewer persons their lives, than that one aphorism of *Hippocrates**, which teaching, 'That if a teeming woman be let blood, she will miscarry,' has for divers ages prevailed with great numbers of physicians, to suffer multitudes of their female patients to die under their hands, who might probably have been rescued by a discreet phlebotomy, which experience hath assured us (whatever the close of the aphorism says to the contrary) to have been sometimes not only safely, but usefully employed, even when the infant is grown pretty big. But my respect for so great a person as *Hippocrates* makes me content it should be thought, that, till of late, physicians have for the most part mistaken their dictator's meaning in this aphorism, provided it be granted me, that through this mistake numbers of teeming women have been suffered to perish, who might probably, by the seasonable loss of some of their blood, have prevented that of their lives.

How prejudicial the mistake of that aphorism (that if teeming women be let blood, they will miscarry) hath been to female patients.

AND if an error, which occasioned only a fault of omission, hath been so prejudicial to mankind, I suppose you will readily grant, that those errors of physicians, that are apt to produce faults of commission, and rash attempts, may prove much more hurtful. And so much I find to be acknowledged by *Galen*, in that honest and excellent passage of his, in his *Comment upon the Aphorisms*, where having mentioned the danger of trying conclusions upon men, by reason of the nobleness of the subject; and having added, that the physicians art is not like that of a potter, a carpenter, or the like, where a man may freely try what he pleases to gratify his curiosity, or satisfy himself

Comment. in Aph. I. Lib. I.

* *Hipp. Aph. Lib. V. Γυνή τις γὰρ ἐχούσα, φλεβοτομαδίτῃ ἐκτινέσκει· καὶ μᾶλλον εἰ μείζον ἐστὶ τὸ ἔμβρυον.*

about his notions, because, that if he spoils (for instance) the wood he works on, no body is endangered by his miscarriage; he thus concludes, *In corpore autem humano ea tentare, quæ non sunt experientium comprobata periculo, non vacat; cum temerariæ experientie finis sit totius animantis internecio*; 'But I dare not try those things upon human body, which have not been before tried upon former experiences; for the end of such rash experiments may be the ruin of all lives.'

The interest of this knowledge to the happiness and life of man.

AND indeed, since the physician borrows his principles of the naturalist, I cannot but somewhat admire to see divers persons, who are by themselves and others thought such wise men, think the study of natural philosophy of small concernment: for when by their policy or good fortune, they have acquired never so much wealth or power, and all other transitory goods, and are blest with children to inherit them, if the principles of natural philosophy be mislaid, we oftentimes see the ignorance or the mistake of a doctor, deprive them of all at once, and shew how dangerous it is to be solicitous of the means of attaining the accommodations of life, with the contempt of that knowledge, which in very many cases is humanly necessary to the preservation of life itself.

The enumeration of those arts, to which this knowledge is profitable.

BUT, *Pyrophilus*, though our unintended prolixity in the former part of our discourse, concerning the usefulness of physiology, oblige us to the greater brevity in this latter part of it; yet, to shew you, that of the two things, which you may remember we told you, *Pythagoras* pronounced most god-like in man, (*The knowledge of truth, and the doing of good*) physiology as well qualifies us for the latter, as it enriches us with the former. It will not be amiss a little more particularly (though as succinctly as so copious a subject will permit) to consider the probability there is, that no small improvement may be made by men's proficiency in experimental knowledge of those arts, which are the chiefest instruments of man's dominion over the creatures. These arts (to divide them not accurately, but popularly) do serve either to relieve man's necessities, as physick and husbandry; or for his accommodation, as the trades of shoe-makers, dyers, tanners, &c. or for his delight, as the trades of painters, confectioners, perfumers, &c. to all which arts, and many others allied to them, philosophical experiments and observations may, by a knowing naturalist, be made to extend a meliorating influence.

The method or way intended for the ensuing discourse.

If I should, *Pyrophilus*, say this, without offering any thing at all by way of proof, that I say it not inconsiderately, you would, I fear, believe, that I deliver it too slightly for a matter of that moment: and if, on the other side, I should in this discourse, present to you all the particulars, that I think I could without impertinency employ, to countenance what I have said, it would swell this treatise to a volume, and defraud divers of my other essays. And therefore I hold it not unfit to chuse a middle way, and set down, on this occasion, either only, or chiefly those things, which do the most readily occur to me, and do not so properly belong to the rest of my physiological papers. And to avoid confusion, I shall, according to the division newly proposed, employ one section of this second part of the present treatise, in setting down such things, as relate to the improvement of physick. And in the other section, deliver such particulars, as concern those other useful arts, that depend upon natural philosophy. But in regard that (as I have already intimated) the following discourse is to consist chiefly of those things, that belong not to any of my other essays, you will not, I presume, expect that I should handle any subject fully or methodically on this occasion: which warning I especially intend for that part of the ensuing discourse, that relates to physick. For you will easily believe, that I am far from pretending to be a doctor in that faculty: and accordingly, in this and the four following essays, I shall only throw together divers such particulars, as, not belonging to my writing, would perhaps be lost, if I did not lay hold on this opportunity for their preservation; of which they are not

not altogether judged unworthy by some knowing men, whose encouragements, to mention them to you, have dissuaded me from wholly passing by, in this discourse, matters properly medical, what scruples soever I had to venture at speaking of them: especially since I have not now the conveniency to furnish these essays with divers particulars (by some, thought not inconsiderable) which I may, perhaps, be invited to add to them hereafter, if I find by your reception of these, that the others are like to be welcome.

To say something then of physick, and to suppose the fitness of the now received division of it into five parts; the physiological, (the physician taking that in a stricter sense than philosophers, and than we do every where, save in this essay) pathological, semeiotical, hygieinal, and therapeutical; let us briefly take notice, how each of these is indebted to, or capable of being improved by experienced naturalists. And indeed, such is the affinity between natural philosophy and physick, or the dependance of this on that, that we need not wonder at the judicious observation of *Aristotle*, where he thus writes, *Naturalium ferè plurimis & medicorum, qui magis philosophicè artem proficiuntur, illi quidem finiunt ad ea, quæ de medicina; hi vero ex iis quæ de natura, incipiunt quæ de medicina:* ‘This is the course of naturalists and physicians, who prosecute their art philosophically: the naturalist ends where medicine begins, and medicine begins where the naturalist endeth.’ But we must instance these things more particularly: and first for physiology, it is apparent, that the physician takes much of his doctrine in that part of his art from the naturalist: and to mention now no other parts of physiology, in its stricter acception, the experience of our own age may suffice to manifest, what light the anatomical doctrine of man’s body may receive from experiments made on other subjects. For since it were too barbarous, and too great a violation of the laws, not only of divinity but humanity, to dissect human bodies alive, as did *Herophilus* and *Erasistratus*, who (as I find in some of the ancients) obtained of kings the bodies of malefactors for that purpose, and scrupled not to destroy man to know him; and since, nevertheless, divers things in anatomy, as particularly the motion of the blood and chyle cannot be discovered in a dead dissected body (where the cold hath shut up and obliterated many passages) that may be seen in one opened alive; it must be very advantageous to a physician’s anatomical knowledge, to see the dissections of dogs, swine, and other live creatures, made by an inquisitive naturalist: consonantly whereunto we may remember, that the discoveries of the milky vessels in the mesentery by *Asellius*, of those in the thorax by *Pecquet*, and of the *vasa lymphatica* by *Bartholinus*, were first made in brute bodies, though afterwards found to hold in human ones. Nor is it a small convenience to the anatomist, that he may in the bodies of brutes make divers instructive experiments, that he dares not venture on in those of men; as for instance, that late noble, and by many not yet credited experiment, of taking out the spleen of a dog without killing him: for that this experiment may be very useful, we may elsewhere have occasion to shew. And that it is possible to be safely made (though many, I confess, have but unprosperously attempted it, and it hath been lately pronounced impossible in print) ourselves can witness. And because I have not yet met with any author, that professes himself not to relate this experiment (of the exemption of a dog’s spleen) upon the credit of others, but as an eye-witness; I am content to assure you, that that dextrous dissector, Dr. *Folwie* (of whom we formerly made mention) did the last year, at my request, take out the spleen of a young setting-dog I brought him: and that it might not be pretended, the experiment was unfaithfully or favourably made, I did part of it myself, and held the spleen (which was the largest in proportion to his body, that ever I saw) in my hand, whilst he cut asunder the vessels reaching to it, that I might be sure there

The division of physick into five parts.

Arist. lib. de sensu & sensili, cap. 1.

How the physiological part of physick is advantaged by the knowledge of natural philosophy.

That the anatomical doctrine of man’s body receives light from experiments made on other creatures.

Proved by divers instances: as of the finding the lacteals and lymphæducts in brute bodies first.

The experiment of taking out the spleen in dogs.

The same thing done by *Fioravanti* in a woman.

The respiration of frogs divers hours, sometimes days, under water, without suffocation.

Arist. Hist. lib. I. cap. 16.

What use *Aristotle* and *Galen* made of the dissections of brutes.

Anatomy of man counted now in *Muscovy* for inhuman; and the use of skeletons for witchcraft.

Voyage de Muscovie & de Perse, p. 128.

The use of the comparison of the parts of the human body, with those of beasts.

was not the least part of the spleen left unextirpated: and yet this puppy, in less than a fortnight, grew not only well, but as sportive and as wanton as before; which I need not take pains to make you believe, since you often saw him at your mother's house, whence at length he was stolen. And though I remember the famous empirick *Fioravanti*, in one of his Italian books, mentions his having been prevailed with by the importunity of a lady (whom he calls *Marulla Græca*) much afflicted with splenetick distempers, to rid her of her spleen; and adds, that she out-lived the loss of it divers years: yet he, that considers the situation of that part, and the considerableness of vessels belonging to it in human bodies, will probably be apt to think, that though his relation may be credited, his venturousness ought not to be imitated. The experiment also of detaining frogs under water for very many hours (sometimes amounting to some days) without suffocation, may, to him, that knows that frogs have lungs and breathe as well as other terrestrial animals, appear a considerable discovery, in order to the determining the nature of respiration. Besides, the scrupulousness of the parents or friends of the deceased persons deprives us oftentimes of the opportunities of anatomizing the bodies of men, and much more those of women; whereas those of beasts are always and every where to be met with. And it was perhaps, upon some such account, that *Aristotle* said, that the external parts of the body were best known in men, the internal in beasts; *Sunt enim* (says he, speaking of the inward parts) *hominum imprimis incertæ atque incognitæ; quamobrem ad ceterorum animalium partes, quarum similes sunt humane, referentes eas contemplari debemus.* 'The parts of human body are unknown, and therefore we ought to consider them by the parts of other animals, to which they are like.' And questionless in many of them, the frame of the parts is so like that of those answerable in men, that he that is but moderately skilled in androtomy (as some of the moderns call the dissection of man's body, to distinguish it from zootomy, as they name the dissections of the bodies of other animals) may, with due diligence and industry, not despicably improve his anatomical knowledge. In confirmation of which truth, give me leave to observe to you, that though *Galen* hath left to us so many, and by physicians so much magnified anatomical treatises; yet not only divers of those modern physicians, that would eclipse his glory, deny him to have learned the skill he pretends to, out of the inspection of the dissected bodies of men or women, or so much as to ever have seen a human anatomy: but I find, even among his admirers, physicians, that acknowledge, that his knives were much more conversant with the bodies of apes, and other brutes, than with those of men, which in his time, those authors say, it was thought little less than irreligious, if not barbarous, to mangle; which is the less to be wondered at, because even in this our age, that great people of the Muscovites, though a Christian and European nation, hath denied physicians the use of anatomy and skeletons; the former, as an inhuman thing; the latter, as fit for little but witchcraft, as we are informed by the applauded writer *Olearius*, secretary to the embassy lately sent by that learned prince, the present duke of *Holstein*, into *Muscovia* and *Perse*. And of this, the same author gives us the instance of one *Quirin*, an excellent German chirurgion, who, for having been found with a skeleton, had much ado to escape with his life, and was commanded to go out of the kingdom, leaving behind him his skeleton, which was also dragged about, and afterwards burnt.

To these things we may add, *Pyrophilus*, that the diligence of zootomists may much contribute to illustrate the doctrine of androtomy, and both inform physicians of the true use of the parts of an human body, and help to decide divers anatomical controversies. For as in general it is scarce possible to learn the true nature of any creature, from the consideration of the single creature it self; so particularly of divers parts of an human body it is very difficult to learn the true use, without consulting the bodies

bodies of other animals, wherein the parts inquired after is by nature either wholly left out as needless, or wherein its differing bigness, or situation, or figure, or connection with, and relation to other parts, may render its use more conspicuous, or at least, more discernible.

Illustrated
by divers
particular
observa-
tions.

THIS truth may be somewhat illustrated by the following observations, which at present offer themselves to my thoughts upon this occasion.

THE lungs of vipers, and other creatures (whose hearts and whose blood, even whilst it circulates, we have always found, as to sense, actually cold) may give us just occasion to inquire a little more warily, whether the great use of respiration be to cool the heart.

THE sudden falling and continuing together, which we may observe in that part at least of a dog's lungs, that lie on the same side with the wound, upon making a large wound in his chest, though the lungs remain untouched, is a considerable experiment, in order to the discovery of the principal organ of respiration.

IF you dexterously take out the hearts of vipers, and of some smaller fishes, whose coldness make them beat much more unfrequently and leisurely, than those of warm animals, the contraction and relaxation of the fibres of the heart may be distinctly observed, in order to the deciding or reconciling the controversy about the cause and manner of the heart's motion, betwixt those learned modern anatomists, that contend, some of them, for Dr. *Harvey's* opinion; and others, for that of the Cartesians.

TOWARDS satisfying my self in which difficulty, I remember, I have sometimes taken the heart of a flounder, and having cut it transversely into two parts, and pressed out, and with a linnen cloth wiped off, the blood contained in each of them, I observed, that for a considerable space of time, the severed and bloodless parts held on their former contraction and relaxation. And once, I remember, that I observed, not without wonder, that the severed portions of a flounder's heart did, not only after the blood was drained, move as before, but the whole heart observed for a pretty while such a succession of motion in its divided and exsanguious pieces, as I had taken notice of in them, whilst they were coherent, and as you may with pleasure both see and feel in the intire heart of the same fish.

SOME of the other controversies agitated among anatomists and philosophers, concerning the use of the heart, and concerning the principal seat of life and sense, may also receive light from such experiments, that we made in the bodies of brutes, as we could not of men.

AND the first of these, that we shall mention, shall be an experiment, that we remember ourselves formerly to have made upon frogs. For having opened one of them alive, and carefully cut out his heart, without closing up the orifice of the wound (which we had made wider than was necessary) the frog notwithstanding leaped up and down the room as before, dragging his entrails (that hung out) after him; and, when he rested, would upon a puncture leap again, and being put into the water, would swim, whilst I felt his heart beating betwixt my fingers. The hearts of others of them were taken out at an incision, no greater than was requisite for that purpose: when we had stitched or pinned up the wound, we observed them to leap more frequently and vigorously than the former: they would, as before they were hurt, close and open their eye-lids upon occasion. Being put into a vessel not full of water, they would as orderly display their fore and hinder legs in the manner requisite to swimming, as if they wanted none of their parts, especially not their hearts; they would rest themselves, sometimes upon the surface of the water, sometimes at the bottom of it; and sometimes also they would nimbly leap, first out of the vessel, and then about the room, surving the exsection of their hearts, some about an hour, and some longer. And that,

which

Divers motions and actions of frogs after their hearts were cut out.

which was further remarkable in this experiment, was, that we could, by gently pressing their breast and belly with our fingers, make them, almost at pleasure, make such a noise, as to the by-standers made them seem to croak. But how this experiment will be reconciled to the doctrine ascribed to Mr. *Hobbes*, or to that of the Aristotelians, who tell us, that their master taught the heart to be the seat of sense (whence also, though erroneously, he made it the original of the nerves) let those, that are pleased to concern themselves to maintain all his opinions, consider.

Observations of the motion of a chicken's heart, after the head and other parts were cut off.

AND whereas frogs, though they can move thus long without the heart, yet they cannot at all bear the exemption or spoiling of the brain; we will add what we have observed, even in hot animals, whose life is conceived to be much more suddenly dissipable, and the motion of each part much more dependent upon the influence of the brain: we opened then an egg, wherein the chick was not only perfectly formed, but well furnished with feathers; and having taken him out of the membrane, that involved him, and the liquors he swam in, and laid him on his back on a flat piece of glass, we clipped away, with a pair of scissors, the head and the breast-bone; whereby the heart became exposed to view, but remained fastened to the headless trunk: and the chick lying in this posture, the heart continued to beat above a full hour, and the ears seemed to retain their motion a pretty while after the heart itself had lost his; the motion of none of the other parts appearing many moments to survive the loss of the head: and, which is most considerable, the seemingly dead heart was divers times excited to new, though quickly ceasing motion, upon the puncture of a pin, or the point of a pen-knife. And to evince, that this was no casual thing, the next day we dealt with the chick of another egg, taken from the same hen, after the above-recited manner; and when the motion of the heart and ears began to cease, we excited it again, by placing the glass over the warm steam of a vessel full of hot water, bringing still new water from off the fire to continue the heat, when we perceived the former water to begin to cool, and by this means we kept the heart beating for an hour and an half by measure. And at another time for further satisfaction, we did, by these and some other little industries, keep the heart of a somewhat elder chick, though exposed to the open air, in motion, after we had carefully clipped off the head and neck, for the space of (if our memory do not much mis-inform us) two hours and a half by measure. Upon what conjectures we expected so lasting a motion in the heart of a chick, after it had lost the head, and consequently the brain, would be more tedious and less fit to be mentioned in this place, than the strange vivacity we have sometimes, not without wonder, observed in vipers: since not only their hearts clearly severed from their bodies may be observed to beat for some hours (for that is common with them to divers other cold animals) but the body itself may be, sometimes, two or three days after the skin, heart, head, and all the entrails are separated from it, seen to move in a twining or wriggling manner: nay (what is much more) may appear to be manifestly sensible of punctures, being put into a fresh and vivid motion, when it lay still before, upon the being pricked, especially on the spine or marrow, with a pin or needle.

Of the vivacity of dissected vipers,

And tortoises.

AND though tortoises be in the *Indies* many of them very large animals, yet that great traveller *Vincent le Blanc*, in his *French Voyages*, giving a very particular account of those tortoises, which the East-Indian king of *Pegu*, (who was much delighted with them) did, with great curiosity, cherish in his ponds, adds this memorable passage as an eye-witness of what he relates: *When the king hath a mind to eat of them, they cut off their heads, and five days after they are prepared; and yet after those five days they are alive, as we have often experienced.* Now although I will not say, that these experiments prove, that either it is in the membrane, that sensation resides (though I have sometimes doubted, whether the nerves themselves be not so sensible, chiefly as they are invested

invested with membranes) or that the brain may not be confined to the head, but may reach into the rest of the body, after another manner than is wont to be taught; yet it may be safely affirmed, that such experiments as these may be of great concernment in reference to the common doctrine of the necessity of unceasing influence from the brain, being so requisite to sense and motion; especially if to the lately mentioned particulars we add, on this occasion, what we have observed of the butterflies, into which silk-worms have been metamorphosed; namely, that they may, not only, like common flies, and divers other winged insects, survive a pretty while the loss of their heads, but may sometimes be capable of procreation after having lost them: as I not long since tried (though not, perhaps, without such a reluctancy as *Aristotle* would have blamed in a naturalist) by cutting off the heads of such butterflies of either sex. *Quamvis enim mas, cui prius amputatum est caput, nequaquam adduci posset (quæcunque insecti illius est salacitas) ut feminam comprimeret, decollata tamen femina marem alacriter admisit. Et licet post horas aliquot coitu insumpas ita requierit immota, ut mortuam per multas horas cogitarem, non solum quia omnem penitus motum perdiderat, & in thorace satis magnum apparebat foramen, quod à parte aliqua corporis simul cum capite à trunco disrupta factum videbatur; verum etiam quoniam eodem permansit statu, idque per plures horas, ultra tempus, quo post coitionem cum mare hujus generis animalcula solent ordiri prolificationem. Tandem verò postquam jam diu de viâ ejus desperatum esset, ova fætare tam confertim capit, ut vel exiguo temporis intervallo eorum plura in manu mea deponeret. An verò prolifica sint futura, nondum comperi.*

Whether there be a necessity of the unceasing influence of the brain to sense and motion.

That the silk-worm butterfly is capable of procreation after the loss of its head.

THEIR opinion, that ascribe the redness of the blood to the colour of the liver, through which it passes, is not discountenanced by the livers of men: but in hen-eggs, about the third or fourth day after incubation (for we have found the circumstances of time much to vary) you may observe the *punctum saliens*, or heart, to be ever and anon full of conspicuously red blood, before the naked eyes can so much as discern a liver, at least before they can discover in it any redness; a yellowness being all I could observe in the parenchyma of the livers of divers chickens perfectly formed, and furnished with feathers, though not great enough to make their way out of the shell. And in divers great fishes I have found the vessels of the liver full of very red blood, though the parenchyma or substance of it were white, or at least did not at all participate, much less impart a sanguine colour.

That the redness of the blood is not to be ascribed to the liver, proved by the inspection of the liver of chickens unhatched.

THE doctrine so unanimously delivered by physicians and chirurgeons, concerning the irreparable loss of the limb of an animal, once violently severed from the body, will appear unfit to be admitted, without some restriction, by what may be experienced in lizards, in lobsters, and craw-fishes, and perhaps in some other living creatures. For of lizards it hath been often observed in hot countries, and even in *France*, that their tails being struck off will grow again. And the like hath been of old observed by *Pliny*; and the experienced *Bontius* delivers it upon his own knowledge in these words: *Hoc in domesticis meis non semel animadverti, dum filii mei lustrabundi bacillo caudas iis decutiebant, quas tamen post diem unum aut alterum ad solitum pabulum revertentes vidi, caudasque iis paulatim reaccrescere*: 'This I have more than once observed in lizards, which I kept in my own house. For my children being at play, when with a rod they had struck off the lizards tails, I saw them within a day or two come out to feed, and their tails then by little and little still increasing and growing bigger.'

That the loss of a limb in all animals is not irreparable.

THAT the claws likewise of lobsters being torn off, another will sometimes grow in the room of it, is not only said by fishermen, but hath been affirmed to me by very credible persons, one of which assured me, that he himself had observed it very often. And I am the more apt to believe it, because the like is to be met with among craw-fishes, which are so like lobsters, that by many they are taken (though not considerably

derately enough) to be but a smaller kind of them. For I remember, that going to look upon a repository, where a multitude of them was kept, and causing divers of the fairest to be thrown up, that I might take the stony concretions, commonly called *oculi cancerorum*, out of their heads, I observed one large fish, that had one of his claws proportionable to the bulk of his body, but the other so short and little, that the greater seemed to be four or five times as big as it; whereupon its good shape and fresh colour seeming to argue it to be but young and growing, invited me to ask one of them, that had the oversight of the fish, whether he had formerly seen any claws torn off grow again, he affirmed to me, that in that sort of fish it was very usual.

That notwithstanding the great solution and digestion of meat in the stomachs of fishes, no sensible acidity is found there.

I COULD also tell you, how fruitlessly I have endeavoured to discover that stomachical acidity, to which many of our modern physicians are pleased to ascribe the first digestion of the nutriment of animals, in the purposely dissected stomachs of ravenous sea-fishes; in whose stomachs, though our taste could not perceive any sensible acidity, yet we found in one of them a couple of fishes, each of them about a foot long: whereof the one, which seemed to have been but newly devoured, had suffered little or no alteration in the great fish's stomach; but the other had all its outside, save the head, uniformly wasted to a pretty depth, beneath the former surface of the body, and looked as if it had been not boiled, or wrought upon by any considerable heat, but uniformly corroded, like a piece of silver coin kept a while in aqua fortis, according to the criminal tricks of adulterators of money.

Experiments concerning the solution of meats, and their change of colours by acid menstruums.

YET I am loth, till I have perfected what I design in order to that inquiry, either to embrace or reject the opinion I find so general among the moderns, concerning the solution of meat in the stomach by something of acid. And I remember, that when I was considering what might be alledged for, as well as against that opinion, I devised this experiment, among others, in favour of it. I provided a liquor, with which I drenched a piece of a wing of a pullet, having first well crushed it between my fingers, to make some amends for the omission of chewing it; and having a little incorporated the liquor and the muscous flesh, they immediately changed colour, and in about an hour grew to be a kind of jelly, in colour and consistence not unlike quince marmalade. This mixture, by the next morning, did, as I expected, turn to a deep blood-red, or sometimes rather a lovely purple liquor, though all his while there had been no external heat employed to promote the action of the menstruum. And the like experiment I tryed also with a piece of mutton, with bread, and a piece of veal, and other edible things, which at that time occurred to me; and found the operation of the liquor almost uniform, though it seemed to act most effectually upon flesh. And to gratify in some measure your curiosity, *Pyrophilus*, I am content to tell you, that the menstruum was drawn from vitriol, and that with the bare oil of it I have (though I could not with aqua fortis) performed no less than what I have yet mentioned: but lest this should be thought a digression, let it suffice to have, on this occasion, mentioned thus much upon the by.

To what we lately took notice of concerning the heart may be added, that on the sea-coast of *Ireland*, I observed a sort of fishes about the bigness of mackrels, whose hearts were of an inverted figure, compared to those of other animals; the basis or broad end of the heart being nearest the tail, and the acuminate part or apex being coherent to the great artery, and respecting the head.

To all these trifling observations divers more considerable ones might be added, but they may be more seasonably insisted on elsewhere; and those already mentioned may suffice to let you see, that the naturalist his zootomy may be very serviceable to the physician in his anatomical inquiries.

NOR is it only by the dissection of various animals, that the naturalist may promote the anatomist's knowledge, but perhaps also he may do it by devising ways to make the dead bodies of men, and other animals, keep longer than naturally they would do. For since experience teaches us, that men find it very easy to forget the originations, windings, branchings, insertions, and other circumstances of particular vessels, and other parts of the body, as well as those, that study botanicks, are wont to complain of their easy forgetting the shapes, differences, and alterations of smaller plants; it cannot but be a great help to the student of anatomy to be able to preserve the parts of human bodies, and those of other animals, especially such monsters, as are of a very singular or instructive fabrick, so long, that he may have recourse to them at pleasure, and contemplate each of them so often and so considerately, till he have taken sufficient notice of the shape, situation, connection, &c. of the vessel, bone, or other part, and firmly impressed an idea of it upon his memory. We find our selves much helped to retain in our memory the figures and differences of vegetables, by those books, which some curious botanists make, wherein the plants themselves, artificially dried, are displayed upon, and fastened to leaves of white paper. If it were not for one of those books, wherein I have in one vast volume almost all the plants of one of the chief physick-gardens in *Europe*, I should every year forget, by the end of winter, to know again most of the smaller plants I had learned to take notice of in the spring. And by the way it is observable, how long plants, by being carefully indeed, but barely dried in the shade betwixt sheets of paper, which help to soak up the superfluous moisture, may be preserved. For I have divers years had an herbal, wherein several of the flowers, and other plants, retain their native yellow and blue, &c. (but somewhat faint) though by the date it appeared to be 22 or 23 years old. And I am apt to think, that it would be very possible for anatomists also to preserve the bodies they contemplate for a considerable time: for experience hath informed us in good number of such animals, that butterflies, and divers other flying insects, may have their shape and colours preserved, I know not how long, by running them through in some convenient part with pins, and therewith sticking them to the inside of large boxes. And on this occasion, I remember, that having sometimes reflected upon the lasting of spiders, flies, and other small living creatures, that having been casually enclosed in amber whilst it was soft, are ever preserved entire and uncorrupted, I thought it not amiss to try, whether some substance, like amber (at least as to the newly mentioned use of it) might not easily be prepared by art. And hereupon I quickly found, that by taking good clear *Venice* turpentine, and gently evaporating away about a third part of it, (sometimes more, sometimes less, according to the exigency of my particular purpose;) I could make a reddish gum, diaphanous and without bubbles, which would melt with a very gentle heat, and easily (being suffered to cool) become again so hard as to be brittle. This resinous substance should be melted with as little heat as is possible, (and therefore should be first powdered) that the texture of the vegetable or animal bodies to be cased over with it, might receive the less alteration: and when it is brought to the requisite degree of fluidity, then the body to be preserved (being, if that be needful, struck through with a pin) must be gently plunged into it, and presently taken out and suffered leisurely to cool, being turned from time to time this way or that way, if there be occasion, that the investing matter may be every where of an equal thickness upon it. And if at the first time the case be not thick enough, it may again, when it is cold, be immersed into the liquid matter, (as chandlers are wont to thicken their candles, by dipping them frequently into melted tallow) of which some will every way adhere to it. And though these cases be inferior to amber, in regard of their being more apt to be sullied by dust, or otherwise; yet that inconvenience may be easily

Ways of artificial drying and preservation of plants.

And insects

remedied, by keeping them shut up in glassess or boxes, at those times, when one hath not occasion to consider them. And their clearness (especially if they be thin) and their smooth surfaces, together with their exactly keeping out the air from the body they enclose, may, perhaps, make so cheap and so easy an experiment a not unwelcome trifle, especially considering, how easily it is capable of improvement.

And more bulky bodies.

BUT to return to the preservation of more bulky bodies, it is a known thing to the collectors of rarities, that the external idea of fishes, crocodiles, birds, and even horses, may be preserved for many years, by taking out the more corruptible parts, and stuffing their prepared skins with any convenient matter. And that the internal membranous parts of bodies may be long and easily kept from putrefaction, is not unknown to many anatomists. And not to mention what we have tried of this sort, we have seen the veins, arteries, and nerves of a human body, laid out in their natural situation upon three boards, by the pains and skill of an accurate anatomist of *Padua*. And elsewhere, *Uterum vidimus atque omnia mulieris genitalia*, together with the bladder, all displayed upon a board, preserved for many years so entire, and in a situation so near the natural, that this scheme was far more instructive, than the most accurate printed one could possibly be. We have likewise known the flesh of vipers, kept not only sweet but efficacious, for divers years, by the smoke of a peculiar powder, chiefly consisting of aromattick ingredients, and of which you, *Pyrophilus*, may command the composition.

Particularly the schemes of divers parts of human body.

WE have also seen the skeleton of a monkey, made by an excellent French surgeon of our acquaintance, whereon the tendons and fibres of the muscles were so preserved, that it was looked upon as a rarity, very useful to shew their originations and insertions, and to explain the motions of the limbs: and perhaps there may be some way to keep the arteries and the veins too, when they are emptied of blood, plump, and unapt to shrink overmuch, by filling them betimes with some such substance, as, though fluid enough when it is injected to run into the branches of the vessels, will afterwards quickly grow hard. Such may be the liquid plaister of burnt alabaster, formerly mentioned, or ising-glass steeped two days in water, and then boiled up, till a drop of it in the cold will readily turn into a still gelly. Or else *saccharum saturni*, which, if it be dissolved often enough in spirit of vinegar, and the liquor be each time drawn off again, we have observed to be apt to melt with the least heat, and afterwards to grow quickly into a somewhat brittle consistence again. But I must not insist on these fancies, but rather add, that I have known an embryo, wherein the parts have been very perfectly delineated and distinguishable, preserved unputrified for several years; and I think it still continues so, by being seasonably and artificially embalmed with oil (if I much misremember not) of spike. And I have elsewhere seen a large embryo, which after having been preserved many years, by means of another liquor (whose composition I do as yet but guess at) did, when I saw it, appear with such an admirable entireness, plumpness, and freshness, as if it were but newly dead: and that which concurs to make me hope, that some nobler way may be yet found out, for the preservation of dead bodies, is, that I am not convinced, that nothing can powerfully resist putrefaction in such bodies, but things, that are either saline and corrosive, or else hot; nor that the embalming substances cannot be effectually applied, without ripping open the body to be preserved by them. For *Josephus Acosta*, a sober writer, relates, that in certain American mountains, men, and the beasts they ride on, sometimes are killed with the winds, which yet preserve them from putrefaction, without any other help. So insensible a quantity of matter, such as it may be, may, without incision made into the body, both pervade it, and as it were embalm it. I know also a very experienced and sober gentleman, who is much talked of, for curing of cancers in womens breasts, by the outward application of an indolent powder, some of which he also gave me, but I have

Of the preservation of an embryo divers years, by embalming it with oil of spike.

Instances of men in the American mountains killed, and afterwards preserved from putrefaction, only by the wind.

have not yet had the opportunity to make trial of it. And I shall anon tell you, that I have seen a liquor, which, without being at all either acid or caustick, is in some bodies far more effectual against putrefaction, than any of the corrosive spirits of nitre, vitriol, salt, &c. and than any of the other saline liquors, that are yet in use. We have also tried a way of preserving flesh with musk, whose effects seemed not despicable to us, but must not here be insisted on.

Nor were it amiss, that diligent trial were made, what use might be made of spirit of wine, for the preservation of a human body. For this liquor being very limpid, and not greasy, leaves a clear prospect of the bodies immersed in it; and though it do not fret them, as brine, and other sharp things, commonly employed to preserve flesh, are wont to do; yet it hath a notable balsamick faculty, and powerfully resists putrefaction, not only in living bodies (in which, though but outwardly applied, it hath been found of late one of the potentest remedies against gangrenes) but also in dead ones. And I remember, that I have sometimes preserved in it some very soft parts of a body for many months (and perhaps I might have done it for divers years, had I had opportunity) without finding, that the consistence or shape was lost, much less, that they were either putrified or dried up: we have also, by mixing with it spirit of wine, very long preserved a good quantity of blood, so sweet and fluid, that it was wondered at by those, that saw the experiment. Nay, we have for curiosity sake, with this spirit, preserved from further stinking a portion of fish, so stale, that it shined very vividly in the dark; in which experiment, we also aimed at discovering, whether this resplendent quality of the decaying fish would be either cherished or impaired by the spirit of wine, (whose operations in this trial, we elsewhere inform you of) and it would be no very difficult matter for us to improve, by some easy way, this balsamical virtue of spirit of wine, in case you shall think it worth while. But not to anticipate what I may more properly mention to you elsewhere, I shall at present say no more touching the conservation of bodies, since probably by all these, and some other particulars, we may be induced to hope so well of human industry, as not to despair, that in time some such way of preserving the bodies of men, and other animals, will be found out, as may very much facilitate, and advance too, anatomical knowledge. Neither is it only by advancing this, that the naturalist may promote the physiological part of physick: for since the body consists not only of firm and constant parts, as the bones, muscles, heart, liver, &c. but of fluid ones, as the blood, serum, gall, and other juices; and since consequently to the complete knowledge of the use of all the parts, we should investigate not only the structure of the solid ones, but the nature of the fluid ones; the naturalist may do much more than hath yet been done, towards the perfecting of this knowledge, not only by better explicating what it is in general, makes bodies either consistent or fluid, but by examining particularly, and especially in a pyrotechnical way, the nature of the several juices of the body, and by illustrating the alterations, that those juices, and the aliments they are made of, receive in the stomach, heart, liver, kidneys, and other viscera. For although a human body, being the most admirable corporeal piece of workmanship of the omniscient Architect, it is scarce to be hoped, but that even among the things, that happen ordinarily and regularly in it, there will be many, which we shall scarce be able to reach with our understanding, much less to imitate with our hands: yet peradventure, if chymical experiments, and mechanical contrivances, were industriously and judiciously associated by a naturalist profoundly skilled in both, and would make it his business to explain the phenomena of a human body, not only many more of them, than at first one would think, might be made more intelligible than as yet they have been; but divers of them (especially those relating to the motions of the limbs and blood) might be by

Of the use of spirit of wine, for the preservation of bodies from putrefaction.

That the examination of the juices of human body, by the art of chirurgery, may illustrate their use and nature.

That the actions, which are common to men, with other animals, being performed mechanically, the skill of mechanics must be of use to physiology.

artificial engines (consisting as the pattern not only of solid, but liquid and spirituous parts) not ill represented to our very senses: since a human body it self seems to be but an engine, wherein almost, if not more than almost, all the actions common to men with other animals are performed mechanically. But of the difference of these living engines from others, I may elsewhere have a fitter opportunity to discourse to you. For at present, *Pyrophilus*, I have employed so much of the little time my occasions will allow me to spend upon the treatise I am now writing, in making out to you the usefulness of natural philosophy to the physiological part of physick, that I must not only not prosecute this subject, but must both hasten to mention, and to mention the more cursorily its serviceableness to the four remaining parts of the physician's art.

ESSAY II.

Offering some particulars relating to the Pathological part of Physick.

That the naturalist's knowledge may assist the physician to discover the nature and causes of diseases.

Proved by general reason.

AND to say something in the next place of pathology, that the naturalist's knowledge may assist the physician to discover the nature and causes of several diseases, may appear by the light of this consideration, that though divers Paracelsians (taught, as they tell us, by their master) do but erroneously suppose, that man is so properly a microcosm, that of all the sorts of creatures, whereof the macrocosm or universe is made up, he really consists; yet certain is it, that there are many productions, operations, and changes of things, which being as well to be met with in the great, as in the little world, and divers of them disclosing their natures more discernibly in the former, than in the latter; the knowledge of the nature of those things, as they are discoverable out of man's body, may well be supposed capable of illustrating many things in man's body, which receiving some modifications there from the nature of the subject they belong to, pass under the notion of the causes or the symptoms of diseases. If I were now, *Pyrophilus*, to discourse to you at large of this subject, I think I could convince you of the truth of what I have proposed. And certainly, unless a physician be (which yet I fear every one is not) so much a naturalist, as to know, how heat and cold, and fluidity, and compactness, and fermentation, and putrefaction, and viscosity, and coagulation, and dissolution, and such like qualities, are generated and destroyed in the generality of bodies, he will be often very much to seek, when he is to investigate the causes of preternatural accidents in men's bodies; whereof a great many depend on the presence, or change, or vanishing of some or other of the enumerated qualities, in some of the fluid or solid substances that constitute the body. And that the explications of a skilful naturalist may add much to what has hitherto commonly been taught concerning the nature and origin of those qualities in physicians schools, a little comparing of the vulgar doctrine with those various phenomena, to be met with among natural things, that ought to be, and yet seem not to be, explicable by it, will easily manifest to you. And questionless it is a great advantage to have been taught, by variety of experiments in other bodies, the differing ways, whereby nature sometimes produces the same effects. For since we know very little *à priori*, the observation of many such effects, manifesting, that nature doth actually produce them so and so, suggests to us several ways of explicating the same phenomenon, some of which

we should perhaps never else have dreamed of. Which ought to be esteemed no small advantage to the physician; since he, that knows but one or few of nature's ways of working, and consequently is likely to ignore divers of those, whereby the proposed disease (or symptom of it) may be produced, must sometimes conclude, that precisely such or such a thing is the determinate cause of it, and apply his method of relieving his patient accordingly; which often proves very prejudicial to the poor patient, who dearly pays for his physician's not knowing, that the quality, that occasions the distemper, may be as probably, if not more rationally, deduced from another origin, than from that, which is presumed. This will scarce be doubted by him, that knows how much more likely explications than those applauded some ages since, of divers things, that happen as well within as without the body, have been given by later naturalists, both philosophers and physicians: and how much the theory of the stone, and many other diseases, that has been given us by those many physicians, that would needs deduce all the phænomena of diseases from heat, cold, and other elementary qualities, is inferior to the account given us of them by those ingenious moderns, that have applied to the advancement of pathology, the circulation of the blood, the motion of the chyle by the milky vessels to the heart, the consideration of the effects deducible from the pores of greater bodies, and the motion and figuration of the minute parts, together with some of the more known chymical experiments: though both of those, and of the other helps mentioned just before them, I fear men have hitherto been far enough from making the best use, which I hope it will daily more and more appear they are capable of being put to. He that has not had the curiosity to inquire out, and consider the ways, whereby stones may be generated out of the body, not only must be unable satisfactorily to explicate how they come to be produced in the kidneys and in the bladder, but will, perhaps, scarce keep himself from embracing such errors, because authorized by the suffrage of eminent physicians, as the knowledge I am recommending would easily protect them from. For we find divers famous, and, otherwise, learned doctors, who (probably because they had not taken notice of any other way of hardening a matter, once soft, into a stone-like consistence) have believed and taught that the stone of the kidneys is produced there by slime baked by the heat and dryness of the part; as a portion of soft clay may, by external heat, be turned into a brick or tile. And accordingly they have, for cure, thought it sufficient to make use of store of remedies to moisten and cool the kidneys; which, though in some bodies this be very convenient, are yet far inferior in efficacy to those nobler medicines, that by specific qualities and properties are averse to such coagulations as produce the stone. But (not to mention what a physician skilled in anatomy would object against this theory from the nature of the part affected) it is not unlike, the embracers of this hypothesis would not have acquiesced in it, if they had seen those putrefactions out of the bodies of men, which we elsewhere mentioned. For those would have informed them, that a liquor abounding with petrescent parts may not only turn wood (as I have observed in a petrifying spring) into a kind of stone, and may give to cheese and moss, without spoiling their pristine appearance, a strong hardness and weight; but may also produce large and finely shaped crystalline bodies (though those I tried were much less hard than crystal) in the bosom of the cold water. Which brings into my mind, that I have divers times produced a body of an almost stony hardness in less than half an hour, even in the midst of the water, by tying up in a rag, about the quantity of a nutmeg of well and recently calcined alabaster, which being thus tied up and thrown into the bottom of a basin full of water, did there speedily harden into lapideous concretion. And that even in the bodies of animals themselves, such concretions may be generated much otherwise, than the

By particular instances of the cause of the stone in the kidneys.

The cause of that disease illustrated by the putrefaction of wood, cheese, moss, water, &c.

The origin
of *Helmont's*
Alba Offa,
and *Paracelsus's*
Duelech, by the
mixture of
spirit of
wine and
spirit of u-
rine, an ex-
ample of
the genera-
tion of the
stone. *Hel-*
mont: de
Lith. cap.
3 & 4.

the hypothesis we have been speaking of supposes, may appear by what happens to craw-fishes, which though cold animals, and living in the waters, have generated at certain seasons in their heads, concretions, which for their hard and pulverizable consistence, divers authors called *lapides cancrorum*, though in the shops they are often, but abusively styled *oculi cancrorum*. And such strong concretions are affirmed to be generated in these fishes every year, which I the less scrupled at, because I have not found them at all times in the head of the fish. And besides these and many more concretions, that had they been observed by the physicians we have been speaking of, might easily have kept them from acquiescing in, and maintaining their improbable explication of the manner of the stone's nativity; there is yet another kind of coagulation, which may both be added to the former, and perhaps also may serve to recommend the use of chymical experiments, investigating the causes of diseases. This is made by the mixture of exquisitely dephlegmed spirit of fermented human urine, with as exactly rectified spirit of wine: for upon the confusion of those two volatile liquors in a just proportion, they will both of them, as after *Lullius*, experience hath informed us, suddenly coagulate into a white mass, which *Helmont* calls *Offa Alba*, and by which he endeavours to declare the procreation of the *Duelech*. For supposing himself to have found in human urine a potential *aqua vite*, or vinous spirit, capable of being excited by a putrid ferment, and coagulable by the volatile salt of the same urine, if there were any volatile earth lurking in the liquors; that being apprehended by the uniting spirits, and coagulated with them both, he supposeth there may emerge from the union of those three bodies, such an anomalous concretion, as he, after *Paracelsus*, calls *Duelech*.

That a ter-
restrious
substance
may lurk
undiscovered
in limpid
liquors.

AND that a subtle terrestrious substance may lurk undiscovered, even in limpid liquors, may appear not only in wine, which rejects and fastens to the sides of the containing vessel, a tartar, abounding in terrestrious feculency; and in common urine of healthy men, which, though clear, at its first emission into the urinal, does, after a little rest there, let fall an hypostasis, or sediment, which, if distilled before fermentation, leaves in the bottom of the cucurbit an earthy substance, and commonly some gravel: but even in rectified spirit of urine it self I have had opportunity to observe, that after very long keeping, there hath spontaneously precipitated a feculency, copious enough in proportion to the liquor, that afforded it. Nay, in another parcel of spirit of urine, that hath been kept much longer than that already mentioned, we observed the other day, that not only there was a terrestrial residue fallen to the bottom of the glass; but to the sides of it, as far as the liquor reached, there adhered a great multitude of small concretions; which, as far as appeared by looking on them through the crystal phial, to whose insides they are fastened, were no other than little grains of gravel, such as are often found sticking to the insides of urinals, employed by calculous persons.

To which we might add an experiment of ours, whereby we are wont almost in a moment, by barely mixing together a couple of liquors both of them distilled and transparent, and yet not both of them saline, to thicken them very notably and permanently, insomuch that they seem not to precipitate each other; yet having once, for curiosity-sake, distilled them with a pretty strong fire, I obtained a great quantity (as I remember, a fourth of the whole mixture) of a blackish mass, that was not only coagulated and dry, but even brittle. But of the coagulation of distilled liquors, such as even chymists themselves are not wont to look upon as at all disposed to coagulation, I may elsewhere have a better opportunity to entertain you, and therefore I shall forbear to do it now.

AND

AND by this way, *Pyrophilus*, doth *Helmont*, if I understand him aright, attempt to make out the generation of the stone in human bodies: in which theory though some difficulties do yet keep me from acquiescing, yet besides that, perhaps what you will meet with by and by (about the distillation of the *Ducleck*) may make you the less wonder at this explication; besides this, I say, granting that none of the enumerated ways of petrescency (if I may so speak) deserve to be looked upon as satisfactory; yet to give so much as an account not very absurd, of a disease so anomalous and abstruse, and hitherto so unluckily explicated by physicians, is perhaps more difficult, than it were to give (at least) a plausible account of divers other distempers.

AND possibly it may be safely enough affirmed, that not only physiology, in its full extent, but that handmaid to it, which is called chymistry, may not a little contribute to clear up the nature of both of the digestions, and of those deficiencies or aberrations in them, which produce a great part of diseases; especially if we allow what, as well physicians, as Spagyristis agree in, (whether warily enough or not, I shall not now dispute) viz. that whatever is separable from bodies by the fire, was, as a constituent element (or principle) pre-existent in them.

The use of chymistry in explaining the nature of, and aberrations in our digestions.

PERHAPS I need not mind you, *Pyrophilus*, that it is usual with the merely Galenical doctors themselves to explicate the nature of catarrhs, by comparing the stomach to a seething-pot, and the head to an alembick, where the ascending vapours, being, by the coldness of the brain, condensed into a liquor, sometimes distil upon the lungs, and sometimes fall upon other weakened parts: in which explication though for divers reasons I cannot acquiesce, yet it may suffice to shew you, how little scruple many learned men, not like to be partial in the case, would make of employing chymical operations to illustrate the doctrine of diseases. And indeed, since the liquors contained in the body abound, divers of them, with saline or sulphureous parts, he, that hath been by chymistry taught the nature of the several sorts of salts and sulphurs, and both beheld and considered their various actions upon one another, and upon other bodies, seems to have a considerable help to discourse groundedly of the changes and operations of the humours, and other juices contained in the body, which he hath not, that hath never had *Vulcan* for his instructor. He that finds, that there may be acid juices in the stomach, and elsewhere, (as is frequently evident in the sharp liquors, which many stomachs cast up) and that there are also sulphureous salts in the body (as is apparent in blood and urine, which abounds with such:) He that knows that the serum, that swims upon the blood out of the body, is by a gentle heat immediately coagulable into a thick whitish substance, not unlike a custard; and that chymically analyzed blood yields store of volatile sulphureous, but (as far as our trials have hitherto informed us) no acid, saltiness:

Proved by a catalogue of considerable observations.

HE that knows, that these animal salts and spirits may be so powerful, that we have been able with spirit of urine, or of hartshorn, to make a red solution of flowers of sulphur, and that with spirit of urine (though drawn without violence of fire) we have (as we elsewhere more particularly declare) dissolved both in a very gentle heat, and in a very short time, the unopened body of crude copper, so as to make thereof a solution of a rich, deep, and even opacous blue; and that we have done almost the like with unrectified spirit of man's blood:

HE that hath, as we have done, examined by fire (especially produced by the help of a burning-glass) that limpid liquor, that is to be found in the lymphatick vessels, and hath taken notice of that odd consistence, smell, crackling, and other qualities discernible in it by heat:

HE that observes, how acid liquors lose their acidity, by working upon some bodies; as when spirit of vinegar grows almost insipid upon the coral it hath corroded; and how those

those saline liquors, by working upon certain bodies, degenerate into salts of another nature, as we have sometimes observed in oil of vitriol, working upon the fourth part of its weight of quicksilver, and how the contrariety of acid and sulphureous salts makes them sometimes disarm, sometimes, after some ebullition, precipitate each other; and sometimes unite into a third substance, of a differing nature from either of those, from whose coalition it results, as we see in *tartarum vitriolatum*; and, as I have observed, in a salt, I sometimes make to emerge from a due proportion of oil of vitriol and spirit of urine, freed, after conjunction, from their aqueous moisture: And he, in a word, that hath carefully analyzed and made trials on many parts, both of the macrocosm and microcosm, and heedfully applied his experiments made on the former to the illustration of the changes observable in the latter, shall be likely to explicate divers particulars in pathology more intelligibly, than he that is a stranger to chymistry.

That salt and sulphur have more influence in the causation of diseases, than the first qualities, as heat, cold, &c.

AND though I am very unwilling to meddle with medical controversies, and am apt to think, that chymists are wont to speak somewhat too slightly of the humours of the human body, and allow them too little a share in the production of diseases; yet (to skip other reasons) the strange stories related by *Skenkius*, and other eminent physicians, of the corrosiveness of some juices, which, rejected by urine or vomits, have been able to boil on brass, fret linen, and stain silver; together with some odd observations of this nature our selves have had opportunity to make, do very much incline us to believe, that the generality of former physicians have ascribed too much to the humours, under the notion of their being hot and dry, cold and moist, or endowed with such other elementary qualities, and have taken a great deal too little notice of the saline (if I may so speak) and sulphureous properties of things. And in this opinion I am not a little confirmed by the authority of *Hippocrates* himself, both in other passages, and especially where he says, *Non calidum, frigidum, humidum, aut siccum esse, quod magnam agendi vim habet, verum amarum & salum, & dulce & acidum, & insipidum & acerbum, &c.* are the things, which, though inoffensive to the body, whilst they duely allay each other, prove hurtful to it, and dis Temper it, when any of them comes to serve it self from the rest, and grow predominant. And indeed, if the juices of the body were more chymically examined, especially by a naturalist, that knows the ways of making fixed bodies volatile, and volatile fixed, and knows the power of the open air in promoting the former of those operations; it is not improbable, that both many things relating to the nature of the humours, and to the ways of sweetening, acuating, and otherwise altering them, may be detected, and the importance of such discoveries may be discerned.

Observations made upon the liquor, that distends the abdomen in the dropsy.

Paracentesis.

AND perhaps it would add to the usefulness of such an examination, if it were extended to the noxious juices in distempered bodies: such as the rotten phlegm spit up by those whose lungs are disaffected; the slimy excretions voided in the lientery, and the liquor, that distends the *abdomen* in the dropsy and *ascites*: concerning which (to tell you that upon the by) I found, that it was of a differing nature from either water or urine. For a *Paracentesis* being made in the *abdomen* of one dangerously sick of this sort of dropsy, I found, that the liquor would keep a pretty while without putrefaction, (nor did the patient's body, when I afterwards saw it opened, smell almost at all, though the inside of the *abdomen* looked well as near as black, as if it had been sphacelated:) and having steamed away some of it, whilst it was pretty fresh, over a somewhat slow fire, it first coagulated into a substance like whites of eggs, and, by a little farther evaporation, turned to such a glutinous substance, as tradesmen are wont to call size; and being kept longer on the fire grew to be hard like fish-glew, but more brittle, and transparent enough, but with a little tincture of a greenish yellow; and some of the fore-mentioned liquor being distilled in a retort, did towards the end of the

the operation so darken the vessel with a thick blackish oil, as hindered me from discerning what else perhaps I might have seen. And I suppose it may prove a useful instance to the former purpose, if I somewhat circumstantially annex here what occurred to me, when I was accidentally considering of the *calculus humanus*.

HAVING therefore obtained of a skilful lithotomist of my acquaintance divers stones, which he had cut out of men's bladders, I chose a couple of them (which were whitish almost, of equal bigness, and figure, which was near oval, and which together weighed about two ounces and an half :) these with the help of a strong knife I carefully opened, to find whether or no either of them consisted of an intire and uniform matter, (as most other stones, and even some *calculi humani* do;) and I found, that each of them was made up of several shells, as it were successively involving one another, like the rinds of an onion. And such shells, but more soft, and more of a colour, we likewise observed in a great stone taken a while since out of an ox's gall, and sent us for a present: and though all of these were of an almost stony hardness, yet that hardness was not equal in them all; and in one of the stones we observed one of the rinds (to make use of that expression) to be of a differing colour both from that which immediately embraced it, and from that which it immediately embraced: some of these rinds equalled in thickness the length of a barley-corn, and others were somewhat thinner. Though they did closely embrace one another, yet they were actually separable, as well as visibly distinguishable. And proceeding very warily in the breaking one of these stones, we found, that in the center of it there lay a small and soft oval stone, as it were the kernel of those conglomerated shells; and this kernel lay so loose, that with a little industry and patience we picked it out of the shell, and kept it by us as a rarity. This done, being desirous to know, whether chymical tortures would force these concretes to a farther confession of their nature, we caused them to be finely powdered, and put into a small but strongly coated glass-retort, whereunto luting a much larger retort for a receiver, we found, that these two ounces and half of powder, being distilled for some hours in a naked fire, afforded us great store of volatile salt (partly grey and partly white) which almost covered the inside of the receiver, and a pretty quantity of reddish spirit, which in the receiver itself soon coagulated into salt: and having severed our vessels, we found in the neck of the receiver a very little darkish oil, but in the neck of the retort a greater quantity of the same adust oil, incorporated with a pretty quantity of volatile salt, whose smell did really recall to my mind that peculiar kind of stink, which I had sometimes taken notice of in the volatile salt of unfermented urine; nor were the tastes of these two salts unlike. The *caput mortuum* consisted of a fine, light, coal-black powder, not unlike the finest sort of soot; and by weighing but of six drachms, informed us, that above two thirds of the distilled *calculi humani* had been, as being volatile, forced from the terrestrial parts, even in a close vessel, wherein the *caput mortuum*, though it were left insipid enough, yet retained stink enough to make us think it still contained pretty store of heavy oil: as indeed, having put it into a crucible, and kept it a competent while in a stronger fire, we found it reduced to about two drachms of a brittle mass of insipid white calx, which did not slack, or fall asunder like lime, when it is cast into the water.

To this example of the usefulness of chymistry, to discover the unobserved, and otherwise scarce discoverable difference of the *calculus humanus* from other stones, we may venture to add, that though some Paracelsians do take too much liberty, when they crudely tell us, that there are arsenical, vitriolate, aluminous, and other mineral substances, generated in human bodies; yet if they had more warily proposed their doctrine, it would not perhaps appear so absurd, as they are wont to think it, who considering only the nature of the aliments men usually feed upon, cannot conceive,

Observations on the calculus humanus.

Of the changes, that may reasonably be thought to happen to our aliments within the body.

that such being but either animals or vegetables, can by so gentle a heat as that of man's body, (by which they suppose all the changes of the aliments must be effected) be exalted to an energy like that of such bodies, as are composed of active mineral substances, and have some of them perchance acquired a violence of operation from the fire. But we see, that concretions, so like stones, (which belong to the mineral kingdom) as to pass generally for such, may be produced in the bodies not only of men but of sucking children, whose aliment is fluid milk: and it seems a mistake to imagine (how many soever do so) that heat must needs be efficient of all the changes the matter of our aliments may happen to undergo in a human body; where there are strainers, and solvents, and new mixtions, and perhaps ferments, and divers other powerful agents, which by successively working upon the assumed matter, may so fashion and qualify it, as, in some cases, to bring the more disposed part of it to be not unlike even fossile salts, or other mineral substances. A very eminent person was lately complaining to me, that in the fits of a distemper, which almost as much puzzles her physicians as herself, she sometimes vomits up something so sharp and fretting, that, after it hath burnt her throat in its passage, almost like scalding water, it doth not only stain the silver vessels, that received it, but also work upon them as if it were a corrosive menstruum. And there died a while since a very intelligent person, much employed in publick affairs, who complained to me, that in the fits of the strange distemper he laboured under, he divers times observed, that that part of his pillow, which his breath passed along, would by the strange fuliginous steams, which that carried off with it, be blacked over, as if it had been held in some sooty smoke or other.

Illustrated
by the
example of
juices out of
the body.

WE may also consider, that the rain-water, which in its passage through a vine, or an apricock-tree, or the like plants is turned into a sweet fruit; in its passage through those plants, that bear lemons and barberries, is transmuted into a liquor sharp enough to corrode, not only pearls but coral, *lapides cancerorum*, and other hard concretes, as spirit of vitriol would do. And writers of unsuspected credit affirm, that an Indian fruit, (whose name I cannot readily call to mind) will speedily corrode and waste the very steel knives it is cut with, if its juice be left long upon them: and we see, that some sorts even of our apples and pears will quickly black the blades of knives on which the juice is suffered to continue. And lest what I freshly mentioned about lemon-trees, should be questioned, I will here add, that I remember also, that I have made not only some other hot and strongly tasted herbs, but even a ranunculus it self, to grow and increase notably in weight as well as bulk, though I fed it but with fair water; and allowed it nothing else to shoot its root into. Wherefore since this plant is reckoned amongst those, that either are poisonous, or want but little of being so; and since its operation is so violent, that this sort of vegetables is taken notice of from the experience of country people, to be able by outward application to draw blisters, and since nevertheless that, which this plant, without any heat discernible by the touch, transmutes into so virulent a substance, is but so unactive a body as water; why may not such aliments, as may have in them divers parts of a far more operative nature, be in a human body, by an unusual concourse of causes and circumstances, so altered and exalted, as to approach in operations (especially upon the more tender parts) to those of fossile salts or other minerals? So that a chymist might upon such an account, without any great absurdity, teach some parcels of morbidick matter to be of an arsenical, or vitriolate, or an antimonial nature, especially since we see, that sometimes cancers, ulcers, and sharp juices generated in the body, do by their vitiating and wasting the invaded parts, but too much emulate the pernicious operations of arsenick, and of fretting salts: and the infusion of antimony doth scarce more stimulate nature

to

to disburthen her self both upwards and downwards, than doth sometimes an humour, such as that, which causes the *cholera morbus*, and perhaps more violent diseases.

AND that such degeneration of innocent aliments should sometimes happen in decomposed bodies, you will perhaps think the less strange, if you duly perpend what I lately mentioned of the transmutation of water into hot and vesicatory substances; and if thereto I annex, that from a single pound of so common and temperate an aliment as bread, I can by an easy way, (and that without addition) obtain many ounces of a menstruum, which (as trial has informed) will work more powerfully upon bodies more compact than some hard minerals, or perhaps glass it self, than a wary chymist would expect to see aqua fortis do. These things I have mentioned, *Pyrophilus*, to intimate some of the reasons, why I think chymical experiments may be usefully applied, to illustrate some things in pathology, either by imitating out of the body the productions of some sorts of morbidick matter, or by such resolutions as that, which is generated in the body, as may conduce to the discovery of its nature. And not that I think, as Spagyrist do, the experiments or notions of vulgar chymists sufficient to explicate the whole doctrine either of digestion or diseases; for it would be very difficult for them to make out the manner of nutrition, or so much as how they, that feed only on vegetables, should (to propose the difficulty in their own terms) have their blood and urine copiously enriched with a volatile sulphureous salt, of which sort plants are not wont to yield any in distillation. And much more difficult would it be for them, by principles peculiar to chymists, to make out the propagation of hereditary diseases: or how madness, and some other distempers, that do not visibly vitiate the organs of those functions that they pervert, should not only prove hereditary, but lurk very many years in the inheriting person's body, before they begin to disclose themselves; and sometimes too, be transmitted from the grandfather to the grand-child, and skip immediately the intervening son. And therefore I say again, that I pretend not, that vulgar chymistry will enable a physician to explicate all or most of the pathological phenomena; but that true chymistry may assist him to explicate divers of them, which can scarce be solidly explicated without it. And let me add, that he, that thoroughly understands the nature of ferments and fermentations, shall probably be much better able than he, that ignores them, to give a fair account of divers phenomena of several diseases (as well fevers as others) which will perhaps be never thoroughly understood, without an insight into the doctrine of fermentation; in order to which, for that and other reasons, I designed my historical notes touching that subject,

Difference between vulgar and true chymistry.

The use of the knowledge of fermentation.

YET I am not sure, but there may be effervescences, (and perhaps periodical ones) in the blood and other juices of the body without fermentation properly so called. For there may be divers other ways of begetting a preternatural heat in the blood. We often see, that in coughs, when the phlegm is rotten (as they speak) that is, when its former viscous texture is altered, it does no longer stick fast to the vessels of the lungs, to which it obstinately adhered before. And so at certain times other humours in the body, either by growing more fluid themselves, or by some change in the blood, whereby it becomes fitter to dissolve such humours, may swim in, and be circulated with the mass of blood, and thereby occasion preternatural heats; either by their indisposition to be well incorporated therewith; or by altering its texture; or disturbing the wonted motion of its minute parts; or by opposing its due rarefaction, as it passeth through the heat; or by obstructing the more slender vessels; and so hindering the free circulation of the blood through them; perhaps also causing some extravasation, as we see, that wounds and bruises are attended with some inflammation, more or less, of the part affected; or by some other of the ways not now to be declared. And trial hath taught me, that

Of periodical effervescences in the blood without fermentation.

there are liquors, in which the bare admixture of milk, oil, or other liquors, nay or of cold water, will presently occasion a notable heat: and I sometimes employ a menstruum, in which nothing but a little flesh being put, though no visible ebullition ensue, there will in a few minutes be excited a heat intense enough to be troublesome to him, that holds the glass. And yet it seems not necessary, that this should be ascribed to a true fermentation, which may rather proceed from the perturbed motion of the corpuscles of the menstruum, which being by the adventitious liquor or other body put out of their wonted motion, and into an inordinate one, there is produced in the menstruum a brisk confused agitation of the small parts, that compose it; and in such an agitation (from what cause soever it proceeds) the nature of heat seems mainly to consist. But to dispatch, I scarce doubt, but that if in the history of diseases, there were better notice taken of those phenomena, that agree not with the opinions already in request, as well as of those, that are thought consonant to them; and if also chymical trials were skilfully varied, and judiciously applied to this illustrating of pathological phenomena, the former might be made conducing to the better explication of the latter: especially if the business were managed by a naturalist well versed both in chymical experiments, and in anatomy, and the history of diseases, without being too much addicted either to the chymists notions, or the received opinions of physicians.

Of the use
of zoology
to the
knowledge
of diseases.

AND as the naturalist may thus illustrate pathology as a chymist, so may he do the like as a zoologist; for either the true knowledge of anatomy must be much less useful to physicians than they have hitherto believed, or else the discoveries made by recent anatomists of the Asellian, Pecquetian, and Bartholinian vessels, by either overthrowing the received doctrine of digestions, (from whose aberrations many diseases spring) or at least by making divers discoveries in relation to the oeconomy of digestions unknown to the ancients, must probably contribute much to the clearing up of divers pathological difficulties in the explication of some diseases; besides that the very liberty of making those experiments in live beasts, which are not to be made but in living creatures, nor are allowable to be made in living men, may enable a zoologist, by giving us a clearer account of divers parts of the body, to determine divers pathological difficulties springing from either our ignorance or mistakes of the use of those parts, as by the formerly mentioned experiment of the exsection of a live dog's spleen, and a watchful observation of all the diseases upon that account, befalling him and other dogs so served; much light perhaps may be given to the doctrine of the use of the spleen, together with the diseases supposed to depend upon that part, which I fear is hitherto (to the no small prejudice of the sick) by few physicians thoroughly understood, and by many unhappily enough mistaken.

AND here we may represent unto you, *Pyrophilus*, that not only the dissections of sound beasts may assist the physician to discover the like parts of a human body, but the dissections of morbid beasts may sometimes illustrate the doctrine of the causes and seats of diseases. For that this part of pathology has been very much improved by the diligence of modern physicians, by dissecting the bodies of men killed by diseases, we might be justly accused of want of curiosity, or gratitude, if we did not thankfully acknowledge; for indeed much of that improvement of physick, (for which the antients, were they now alive, might envy our new physicians) may, in my poor opinion, be ascribed to their industrious scrutiny of the seat and effects of the peccant matter of diseases in the bodies of those that have been destroyed by them.

AND that the instructions deducible from such observations may be either increased or illustrated by the like observations made in the bodies of beasts, we have been inclined to think, partly by the having chymically analyzed (as they phrase it) the blood of divers brutes, as sheep, deer, &c. and found its phlegm, spirit, salt, and oil, very like

like that of human blood; and partly, by our having observed in the bodies of several brutes, (not excepting fishes) worms, imposthumes, and the like, some of which seemed manifestly to spring from such causes, as are wont to produce resembling distempers in men. And if the acute *Helmont* had been a more diligent dissector of beasts, he would perchance have escaped the error he after others run into (and into which his authority hath tempted others to run) when he affirmed, that the stone was a disease peculiar to men; for that in the bodies of beasts, especially very old ones, stones are sometimes to be found, not only several butchers have assured me, but you may gather partly from that taken out of an ox's gall, which I have formerly mentioned, which was about the bigness of a walnut, but principally from what I elsewhere delivered on purpose to disprove that fond assertion. And greater leisure may, upon another occasion, invite us to mention some pathological observations made in diseased beasts, by which (were we not willing to hasten) we might now perhaps much confirm what we have proposed touching the possibility of illustrating, by such observations, the nature of some of the diseases incident to human bodies.

Helmont's
error re-
futed, that
the stone is a
disease pe-
culiar to
man.

AND here we may also consider, that there are divers explications of particular diseases, or troublesome accidents proposed by physicians, especially since the discovery of the blood's circulation, wherein the compression, obstruction, or irritation of some nerve, or the distension of some vein by too much blood, or some hindrance of the free passage of the blood through this or that particular vessel, is assigned for the cause of this or that disease or symptom. Now in divers of these cases the liberty lately mentioned, that a skilful dissector may take in beasts, to open the body or limbs, to make ligatures strong or weak on the vessels, or other inward parts, as occasion shall require, to leave them there as long as he pleaseth, to prick, or apply sharp liquors to any nervous or membranous part, and whenever he thinks convenient, to dissect the animal again, to observe what change his experiment hath produced there: such a liberty, I say, which is not to be taken in human bodies, may in some case either confirm or confute the theories proposed, and so put an end to divers pathological controversies, and perhaps too occasion the discovery of the true genuine causes of the phenomena disputed of, or of others really as abstruse.

To this let me add, that there is a whole classis of diseases to be met with in physicians books, which proceed not originally from any internal distemper of the patient, but are produced by some exterior poison, and are therefore wont to be called by doctors, *morbi à veneno orti*, to the more accurate knowledge of divers of which diseases experiments made on brutes may not a little conduce. For though I deny not, that some things may be poisonous to man, that are not so to some beasts; and on the contrary (as we have more than once given to a dog, without much harming him, such a quantity of opium, as would probably have sufficed to have killed several men) yet the greater number of poisons being such both to man and brutes, the liberty of exhibiting them, when, and in what manner we please, to these (which we dare not do to him) allows us great opportunities of observing their manner of operation and investigating their nature, as ourselves have tried, and that sometimes with unexpected events (as when lately a cat ran mad, so that her keeper was fain to kill her) upon a large dose of opium which we caused to be given her.

AND on this occasion I shall not scruple to transcribe one observation out of a discourse, I some years since writ to a friend, about the turning poisons into medicines, because that treatise I am like, for certain reasons, to suppress: the words, as I there find them, are these.

‘ BEFORE I take leave of vipers (or adders, as some will have those, that here in England commonly pass for vipers) it will not be impertinent to tell you, that it may

‘ be

That the venom of vipers or adders consists chiefly in the rage and fury, wherewith they bite, and not in any part of the body that hath at all times a mortal property.

‘ be justly doubted; whether they be to be reckoned amongst poisonous creatures, in
 ‘ such a sense as those other venomous creatures, who have in them a constant, and,
 ‘ if I may so speak, gross and tangible poison; for it may be supposed, that the venom
 ‘ of vipers consists chiefly in the rage and fury, wherewith they bite, and not in any
 ‘ part of the body, which hath at all times a mortal property: thus the madness of a
 ‘ dog makes his teeth poisonous, which before were not so. And authors of good re-
 ‘ pute supply us with instances of hurts, in themselves free from danger, that have
 ‘ been made fatal by a venom created by the fierceness of the enraged (though not
 ‘ otherwise poisonous) creatures that inflicted them. And *Baccius*, if I mistake not,
 ‘ in his treatise *de venenis*, tells us a memorable story (whereof he affirms himself to
 ‘ have been an eye-witness) of a man, who was killed within three days, by a slight
 ‘ hurt received in his left hand, from an enraged dunghill-cock; and that no parts of
 ‘ the viper have any constant inherent poison in them, I have been induced to suspect
 ‘ upon this experiment, that dissecting some live vipers, there came in accidentally a
 ‘ strange dog, to whom I gave the head, tail, and gall, (which are the parts supposed
 ‘ to contain the poison) of one of them, and the head and gall of another, wrapt up in
 ‘ meat; after which I locked the little dog up in my own chamber, and watched him;
 ‘ but found not that he was sick, or offered to vomit at all, but only lapped up
 ‘ greedily some drink, which he espied in the room: nor was he alone very jocund,
 ‘ for divers hours that I kept him in, but liked his entertainment so well, that he
 ‘ would afterwards, when he met me in the street, leave those, that kept him, to fawn
 ‘ on and follow me. And having since related this experiment to an inquisitive friend
 ‘ of mine, he assured me, that to satisfy himself further in this particular, he gave to a
 ‘ dog a dozen heads and galls of vipers, without finding them to produce in him any
 ‘ mischievous symptom. To which I shall add, that the old man you know, that
 ‘ makes viper-wine, does it (as himself tells me) by leaving the whole vipers, if they
 ‘ be not very great, perhaps for some months, without taking out the galls, or sepa-
 ‘ rating any other part from them in the wine, till it hath dissolved as much of it as
 ‘ it can.

A certain
 cure for the
 biting of
 vipers.

‘ AND though it may seem somewhat improper, whilst we are discoursing of poisons,
 ‘ to insist on a remedy against them; yet the mention of vipers recalling into my mind
 ‘ a memorable experiment, which I tried against the biting of vipers, I shall chuse
 ‘ rather to decline the dictates of method, than those of charity, which forbids me to
 ‘ suppress a remedy, that may possibly rescue from sudden death a person or other fit
 ‘ to live, or unprepared to die; because it does not strictly belong to the theme,
 ‘ whereto it is referred. The remedy then is this, that as soon as ever a man is bitten,
 ‘ (for if the poison have had time enough to diffuse it self, and gain the mass of blood,
 ‘ I doubt the experiment will scarce succeed) a hot iron be held as near the place, as
 ‘ the patient can possibly endure, till it have, as they speak, drawn out all the venom:
 ‘ which eye-witnesses assure me (for I have not yet seen that my self) will sometimes
 ‘ adhere like a yellowish spot to the surface of the iron. But being upon competent
 ‘ grounds satisfied of the experiment, to convince a physician, that mistrusted it; I
 ‘ last summer hired a man (who doubted it as little as I) to suffer himself to be bitten
 ‘ by a viper; and having in the physician’s house and presence picked out of a good
 ‘ number of them, one of the blackest I could find (those of that colour being suppo-
 ‘ sed the most mischievous) and commanded the fellow to provoke and anger it,
 ‘ (which to my wonder he did, a pretty while before the beast would fasten on him;)
 ‘ at length being by his very rude handling thoroughly exasperated, it bit him with
 ‘ great fury, as it seemed: for immediately his hand began to swell, and the injured
 ‘ part was grown tumid, before we could take from the fire, which was hard by, a
 ‘ knife,

‘ knife, that lay heating there; and having applied it as near as he could suffer it, for
 ‘ about ten or twelve minutes, we found, that the swelling, though it decreased not,
 ‘ did not spread, and the man glad of his money, without farther ceremony, went
 ‘ about his affairs, and told me since, that though the rumour continued a while, he
 ‘ had no other inconvenience attending it, and hath divers times got money by repeat-
 ‘ ing the experiment; though otherwise, by the casual bitings of vipers, he hath been
 ‘ much distressed, and his wife almost killed.’

BUT, *Pyrophilus*, to return to the experiments of poisons made on beasts, we could
 wish physicians were more diligent to make trials of them, not only by giving beasts
 poisons at the mouth, but also by making external applications of them, especially in
 those parts, where the vessels, that convey blood, more approach the surface of the
 body, and also by dexterously wounding determinate veins with instruments dipt in poi-
 sons (especially moist or liquid ones) that being carried by the circulated blood to the
 heart and heat, it may be found, whether their strength be that way more uninfringed,
 and their operation more speedy (or otherwise differing) than if they were taken in at
 the mouth. For I remember sober travellers have shewed me some Indian poisons,
 whose noxious efficacy they affirmed to be, by great intervals of time, differingly mortal,
 according as the slight hurt made by the points of arrows, infected with them, did
 open a capillary or larger vein, and were inflicted on a part more or less distant from
 the heart; but having not yet made any trial of this my self, I dare not build upon it.
 Yet I find, that the formerly commended *Olearius*, in his travels into *Muscovy* and
Persia, takes notice of a venomous insect in *Persia*, which the natives call *Encureck*, and
 which he (how justly I know not) makes to be a kind of *Tarantula*, because it is, as
 that creature, in shape almost like a spider, and speckled, though of twice the bigness
 of a thumb: this insect (says he) instead of stinging or biting, lets his venom fall in
 form of a drop of water, which immediately produces insufferable pains in the part to
 which it fastens; and suddenly penetrating as far as to the stomach, sends up vapours
 to the head, which sends again (to use his expression) so profound a sleep to all the pa-
 tient’s limbs, that it is impossible to awaken him, but by one only remedy, which is to
 crush one of these creatures upon the hurt, whence he abstracts all the poison. Some
 horrid and unusual symptoms of this venom, which yet agree not so well with those,
 that are wont to be produced in persons bitten by *Tarantula*’s, our author proceeds to
 mention; and furnishes us with a proof of what we were lately saying, when we told
 you, that some things were poisonous to men, which were not to some beasts; by ad-
 ding, as an admirable singularity, that the sheep of those parts do not only eat these
 fatal insects, but seek for them. I know also, by sad experience in my self, what an
 outward application even of cantharides can do; for having occasion to have a large
 blister drawn on my neck, the chirurgeon I employed, unknown to me, made use of
 cantharides, among other ingredients of his vesicating plaister, which, a few hours after
 I had taken it, wakened me with excessive torment, to which it put me about the neck
 of my bladder, so that I apprehended it might proceed from some stone unable to get
 out; of which sudden and sensible pain, after I had a while in vain conjectured, what
 might be the cause, I at length suspected that, which was indeed the true one; and
 having sent for the chirurgeon, he confessed to me, upon my demand, that he had put
 some cantharides in his plaister, not thinking it would have had such an operation:
 whereupon I soon relieved my self, by drinking new milk very well sweetened with
 sugar candy.

Of external
 application
 of poisons,
 and letting
 them into
 the veins of
 beasts.

Voyage de
 Muscovie
 & de Perse,
 p. 334.

P O S T S C R I P T.

Experiments of conveying liquid poisons immediately into the mass of blood.

TO enable you, *Pyrophilus*, to gratify those inquisitive persons, that have heard some, and yet but an imperfect report, of a much noised experiment, that was some years ago devised at *Oxford*, and since tried in other places before very illustrious spectators; I am content to take the occasion afforded me, by what was in the foregoing essay lately mentioned concerning the application of poisons, to inform you, that a pretty while after the writing of that essay, I happened to have some discourse about matters of the like nature, with those excellent mathematicians, *Dr. J. Wilkins*, and *Mr. Christopher Wren*; at which the latter of those virtuosi told us, that he thought he could easily contrive a way to convey any liquid poison immediately into the mass of blood. Whereupon our knowledge of his extraordinary sagacity making us very desirous to try what he proposed, I provided a large dog, on which he made his experiment in the presence, and with the assistance of some eminent physicians, and other learned men. His way (which is much better learned by sight than relation) was briefly this: first, to make a small and opportune incision over that part of the hind leg, where the larger vessels that carry the blood, are most easy to be taken hold of: then to make a ligature upon those vessels, and to apply a certain small plate of brass (of above half an inch long, and about a quarter of an inch broad, whose sides were bending inwards) almost of the shape and bigness of the nail of a man's thumb, but somewhat longer. This plate had four little holes in the sides, near the corners, that, by threads passed through them, it might be well fastened to the vessel. And in the same little plate there was also left an aperture, or somewhat large slit, parallel to the sides of it, and almost as long as the plate, that the vein might be there exposed to the lancet, and kept from starting aside. This plate being well fastened on, he made a slit along the vein, from the ligature towards the heart, great enough to put in at it the slender pipe of a syringe, by which I had proposed to have injected a warm solution of opium in sack, that the effect of our experiment might be the more quick and manifest. And accordingly our dextrous experimenter having surmounted the difficulties, which the tortured dog's violent strugglings interposed, conveyed a small dose of the solution or tincture into the opened vessel, whereby, getting into the mass of blood (some quantity of which, it is hard to avoid shedding in the operation) it was quickly, by the circular motion of that, carried to the brain, and other parts of the body. So that we had scarce untied the dog (whose four feet it had been requisite to fasten very strongly to the four corners of the table) before the opium began to disclose its narcotick quality; and almost as soon as he was upon his feet, he began to nod with his head, and falter and reel in his pace, and presently after appeared so stupified, that there were wagers offered his life could not be saved. But I, that was willing to reserve him for further observation, caused him to be whipped up and down a neighbouring garden, whereby being kept awake and in motion, after some time he began to come to himself again, and being led home, and carefully tended, he not only recovered, but began to grow fat so manifestly, that it was admired: but I could not long observe, how it fared with him; for this experiment, and some other trials I made upon him, having made him famous, he was soon after stolen away from me. Succeeding attempts informed us, that the plate was not necessary, if the finger were skilfully employed to support the vessel to be opened; and that a slender quill, fastened to a bladder, containing the matter to be injected, was somewhat more convenient than a syringe; as also, that this notwithstanding, unless the dog were pretty big, and lean, that the vessels might be large enough and easily accessible, the experiment would not easily succeed. The

inventor of it afterwards practised it in the presence of that most learned noble man, the Marquis of *Dorchester*, and found, that a moderate dose of the infusion of *crocus metallorum* did not much move the dog, to whom it was given : but once that he injected a large dose (about two ounces or more) it wrought so soon, and so violently upon a fresh one, that within a few hours after, he vomited up life and all, upon the straw, whereon they had laid him. I afterwards wished, that not only some vehemently working drugs, but their appropriated antidotes, (or else powerful liquid cordials) and also some altering medicines, might be in a plentiful dose injected. And in diureticks a very ingenious anatomist and physician told me, he tried it with very good success. I likewise proposed, that if it could be done, without either too much danger or cruelty, trial might be made upon some human bodies, especially those of malefactors. And some months after, a foreign ambassador, a curious person, at that time residing in *London*, did me the honour to visit me, and informed me, that he had caused trial to be made with infusion of *crocus metallorum*, upon an inferior domestick of his, that deserved to have been hanged ; but that the fellow, as soon as ever the injection began to be made, did (either really or craftily) fall into a swoon, whereby being unwilling to prosecute so hazardous an experiment, they desisted ; without seeing any other effect of it, save, that it was told the ambassador, that it wrought once downward with him, which yet might, perhaps, be occasioned for fear or anguish. But the trials of a very dextrous physician of my acquaintance, in human bodies, will perhaps, when I shall have received a more circumstantial account of them, be not unwelcome to you. And in dogs, you may possibly, from our own observations, receive a further account of an experiment ; of which, I now chiefly designed but to relate to you the rise and first attempts.

ESSAY III.

Containing some particulars relating to the Semeiotical part of Physick.

THE semeiotical part of the physician's art seems capable of the least improvement by natural philosophy. In which yet, first the naturalist may, by illustrating the anatomical and pathological parts, assist the physician to make more certain conjectures from the signs he discovers of the constitution and distempers of his patient. For you will easily believe, that, *ceteris paribus*, he, that better knows the nature of the parts and juices of the body, will be better able to conjecture at the events of diseases, than he that is less skilled in them. And secondly, the naturalist by improving the therapeutical, may at least much change and alter the prognosticks of the duration, ferocity, and event of diseases. For, *Pyrophilus*, it would be considered, that the predictions hitherto current in authors, and commonly made by physicians, suppose the use of the received remedies, and the dogmatical method of physick ; but if there were discovered such generous and commanding medicines, as, by powerfully assisting nature, or nimble proscribing the morbidick matter, that doth either produce, or (though produced by course) cherish sicknesses, might enable nature to hinder the disease from continuing its course, and acting almost all the scenes of its tragedy in the body ; physicians need

That the improvement of the therapeutical would alter the prognosticks in the semeiotical part of physick.

not, in acute diseases, wait so often for a crisis to instruct their prognosticks; and the threatening symptoms of chronical distempers would often prove false prophets.

An instance
to that pur-
pose in the
Peruvian
bark.

To illustrate this but with a not ignoble instance, give me leave to tell you, that when that Peruvian bark, that now begins to be somewhat taken notice of, under the name of the Jesuits powder, had scarce been so much as heard of in this part of *Europe*, I went to visit a virtuoso, who had been for some months afflicted with a quartan ague, so violent and stubborn, that it had frustrated the skill, and almost tired the endeavours of the most eminent doctors of this nation; of one of which, who was then accidentally with his learned patient, I inquired how my friend did, and was answered, that he hoped he would recover, when the season would give him leave; but in the winter he knew no quartans cured. Yet the gentleman acquainting me with his having procured some of the American bark against agues, which we mentioned in a former essay, and I (after having tasted and considered it) having encouraged him, as I have others, to make trial of it, as the strange effects I have observed of it have divers times invited me to do; the candid and learned doctor not only opposed not my persuasions, but added his own to them. And my friend taking two doses of this powdered bark, though it were at the unhopeful season of the year (the winter solstice) and though he scarce found any sensible operation (unless a little by sweat) of the Peruvian medicine, had by the first dose his fit very much lessened, and by the second quite removed. And though through some irregularities of diet (to which that keen appetite, like that of recovering persons, which I have observed this powder to be wont to produce, tempted him) he did, as I then foretold him he would, after missing eight or ten fits, relapse; yet by the repeated use of the same remedy, he again recovered, and hath continued so ever since. Having also lately persuaded the use of the same medicine, in the same disease, to one of the greatest ladies in this nation, she told me the other day, that it immediately, and in unlikely weather, freed her from those fits, from whence she despaired to be delivered till the spring. Having likewise sent some of it to a couple of gentlemen, sick of the like malady, I had word brought me, that one had missed his fits for a month, though in the midst of winter; and the other was by the first dose cured, and continues so. And divers eminent physicians, to whom I have commended the specifick, have used it with such success, that one of the severest of them, though he had formerly despised it, confessed to me, that in a short time he tried it upon eight or nine several persons, without finding it to fail in any, though one of them especially were, before he was called, judged irrecoverable; the obstinate quartan being complicated with other almost as dangerous distempers. And I confess I somewhat wonder, that men have not the curiosity to try the efficacy of this powerful bark in other diseases than agues; it being highly probable, that a medicine, capable to prevail so strongly against so obstinate a disease as a quartan, (wherein most commonly divers of the considerable parts of the body are much affected) cannot be useless to several other distempers. I deny not, that those, that have taken this powder, have divers of them, after having missed six or seven fits, relapsed into them, (as it likewise happened to one of the gentlemen I sent it to) yet (as I have elsewhere told you) it is much, and more than any common remedy does, to stop the fit so long. Nor is it a small matter to be able to give the patient so much breathing time, and allow the physician the opportunity of employing other remedies. And the relapses we speak of, are commonly cured by the same powder; and we have known them prevented, when the medicine hath been administered, not by unskilful persons, but by a prudent physician, who knows how to assist it, by opening and gently purging physick. Wherefore that, which I should be most gladly satisfied of about this remedy, is, whether or no it do indeed, either proscribe the morbidick matter, or so alter its texture as to make it harmless; or
else,

else, whether it doth secretly leave such noxious impressions upon the spleen, guts, or some other important part, as may shorten life, by producing in process of time, either the scurvy, or the dropsy, or some other formidable disease. But because the resolution of this doubt must be a work of time, we must at present refer it to future observation: and therefore shall now subjoin, that if the famous *Riverius* have not, in his learned observations, flattered his own *febrifugum*, whatever he resolved touching this Indian bark, there will not want a safe remedy, which may allow physicians to make more chearful predictions about the lastingness and event of quartans, than have hitherto been usual.

And in
Riverius's
Febrifugum, and a
new cure of
the King's-
evil.
Riverius
in observat.

How painful and stubborn a disease the King's-evil is wont to prove, is scarce more known, than that it is seldom cured without a tedious course of physick: and yet by the herb mentioned in one of the former essays, the young gentleman there spoken of was cured in a short time, and with little or no pain or trouble. And that these are not the only diseases, in which observations, tending to our present purpose, may be made, the following part of this treatise will afford you opportunity to observe.

Vide infra,
c. 9.

I MIGHT add, *Pyrophilus*, that I was lately visited by an ancient chymist, ennobled by divers eminent cures, who promiseth to me an experiment of making very unusual, and yet rational predictions in some abstruse diseases, by a peculiar way of examining the patient's urine. But because some chymists have written extravagantly enough upon a like subject, and because I have not yet made or seen the experiment of it my self, I dare not yet give this new method of foretelling, for an instance of the usefulness of natural philosophy to the semeiotical part of physick. Though I dare not deny but by precipitations, and some other ways, not yet vulgarly practised, of examining the urine, made by the same patient at several times, before, in, and after some notable alteration in his body, divers things (especially in fevers, and other acute diseases) relating to the state of it, may be discovered, especially if thereto be added a skilful and seasonable chymical examen of the other excrements, and vitiated substances of the patient's body.

You will perchance expect, *Pyrophilus*, that on this occasion I should handle that controversy, which is so hotly agitated betwixt the Paracelsians and their adversaries, concerning the curableness of all diseases: but, for aught I can perceive, the difference betwixt the more sober men of both parties is more about words than things, and might be reduced to a much less distance, if men could but calmly consider, that it is one thing to dispute, whether all diseases be curable, and another, whether all persons be recoverable? For a disease may be called incurable, either in its own nature, or by accident; that is, either because such a disease is not be cured in any patient, or that it is so circumstantiated in this or that patient, as not to be naturally curable in him. Now this distinctly and duly considered may conduce much to reconcile the two opinions, if not the parties that maintain them; for neither would a sober Paracelsian affirm, (though *Paracelsus* himself doth somewhere seem to do so) that every disease is curable in every patient, there being some palsies, gouts, or blindnesses, or the like, so obstinate, that (especially if they are born with a man, or inherited from his parents) the tone of some necessary or considerable part of the body being thereby rather abolished, than barely vitiated, it were a folly to promise recovery to such a patient. And on the other side, a moderate Galenist, that is not unacquainted with the discoveries, which these latter ages have made of the power of nature and art, will not be forward to pronounce (as others do, and as the Paracelsians tax the Galenists too indiscriminately for doing) that the gout, (for instance) the dropsy, the dead palsy, and the stone, are diseases universally incurable; since in the writings of *Eraſtus*, and in the observations of *Schenckius*, and others, there are instances recorded of some cures performed of the dropsy, and one or two more of those stubborn diseases, even by Galenical remedies.

That
though no
disease
should be
incurable,
yet every
disease is
not curable
in every
patient.

That the hope of doing greater cures than ordinary hath engaged artists to make profitable trials.

BUT, *Pyrophilus*, though we cannot but disapprove the vain-glorious boasts of *Paracelsus* himself, and some of his followers, who, for all that, lived no longer than other men; yet I think mankind owes something to the chymists, for having put some men in hope of doing greater cures than have been formerly aspired to, or even thought possible, and thereby engage them to make trials and attempts in order thereunto. For not only before men were awakened and excited by the many promises and some great cures of *Arnoldus de Villanova*, *Paracelsus*, *Rulandus*, *Severinus*, and *Helmont*, many physicians were wont to be too forward to pronounce men, troubled with such and such diseases, incurable, and rather detract from nature and art, than confess, that those two could do what ordinary physick could not; but even now, I fear, there are but too many, who, though they will not openly affirm, that such and such diseases are absolutely incurable, yet if a particular patient, troubled with any of them, be presented, they will be very apt to undervalue (at least) if not deride those, that shall attempt and hope to cure him.

Examples of some unexpected and strange cures.

AND I am apt to think, that many a patient hath been suffered to die, whose life might have been saved, if physicians would have but thought it possible to save it. And therefore I think it were no ill piece of service to mankind, if a severe collection were made of the cures of such persons, as have recovered after having been judged irrecoverable by the doctors; that men might no longer excuse their own ignorance by the impotency of nature, and bear the world in hand, as if the art of physick, and their skill, were of the same extent. And the cures, that seem performed by nature her self, need not be left out of such a collection: for still they shew what is possible to be done by natural means, to evacuate the morbidick matter, or alter its nature (how dangerous soever it is grown,) or how far the tone of a part, or strength of the body may be vitiated or impaired, and yet be capable of some restitution. And such an observation I received from our most experienced *Harvey*, when, having consulted him about my weak eyes, he told me, among other things (as a very remarkable one) that he had once a patient (whose name and profession he told me, but I remember not) that had a confirmed cataract in his eye; and yet upon the use of physick, to which he could not ascribe so wonderful an effect, that cataract was perfectly dissipated, and the eye restored to its wonted function. Which brings into my mind another observation, imparted to me a while since by that excellent and experienced lithotomist, *Mr. Holtyer*, who told me, that among the many patients sent to be cured in a great hospital (of which he is one of the chirurgeons) there was a maid of about 18 years of age, who, without the loss of motion, had so lost the sense of feeling in the external parts of her body, that when he had, for trial sake, pinned her handkerchief to her bare neck, she went up and down with it so pinned, without having any sense of what he had done to her. He added, that this maid having remained a great while in the hospital without being cured, *Dr. Harvey*, out of curiosity, visited her sometimes, and suspecting her strange distemper to be chiefly uterine, and curable only by hymeneal exercises, he advised her parents (who sent her not thither out of poverty) to take her home, and provide her a husband, by whom, in effect, she was, according to his prognostick, and to many men's wonder, cured of that strange disease. That in acute sicknesses persons given over by the physicians may recover, the more judicious, even of those Galenists, that are of a despondent temper, will not deny. For not only *Celsus* gives us this sober admonition, *Neque ignorare oportet in acutis morbis fallaces magis notas esse & salutis & mortis*: 'Nor may we be ignorant, that in acute diseases, the notes of life or death are more fallacious?' But even *Hippocrates* himself, who was so skilful in prognosticks, confesses, that *Morborum acutorum non in totum certæ sunt prænunciationes neque salutis neque mortis*: whence the French have a proverbial saying, that *Il vaut mieux estre condamné*

par les medecins, que par le prevoist des mareschaux; as if in English we should say, "it is better to be condemned to die by the doctor, than by the judge." And even in chronical diseases, where events are wont much better to answer physicians predictions, there are sometimes such cures performed, as may encourage human industry, and keep a sick man's friends from forsaking the cure of him, till life it self hath unquestionably forsaken him. For not only it hath been not unfrequently seen, that divers persons, who have been given over by some physicians, have been cured by others, perchance rather more lucky than more skilful; but those, that have been given over, and that too (sometimes rather upon the believed incurableness of the disease, than the personal condition of the patient) even by judicious and experienced physicians, if such as are acquainted but with the ordinary remedies, have been recovered by the use of extraordinarily powerful, and especially, chymical physick. Of such cures I have sometimes met with a few, which, because I may elsewhere relate, I shall now only mention, on this occasion, what I have heard concerning the cures of cancers, performed by Dr. *Harbersfeld*, one of the principal physicians of *Bobemia*. And among other relations of this kind, made me by credible persons, I cannot omit one, that was of a certain English woman, of sixty and odd years of age, who had long lain in an hospital in *Zee-land*, sick of a cancer in the breast, and by this doctor was, with one single inward remedy, perfectly cured in the space of three weeks. For this relation was made me by persons of very strict veracity, the one a doctor of physick, who was an eye-witness of the cure; the other a child of *Cornelius Drebell's*, who not only saw the cure, but knew the woman before, and out of charity brought her to him, that healed her. The same persons likewise informed me, that the chymical liquor the doctor constantly made use of, does, in the dose of about a spoonful or two, work suddenly and nimbly enough by vomit, but hath very quickly ended its operation; so that within an hour or less, after the patient hath taken it, he is commonly well again, and very hungry. And they having presented me some spoonfuls of this liquor, I find the taste to be offensive enough, and not unlike that of vitriol, which, by the taste and emetick operation, I guess to be, at least, its principal ingredient, however it be prepared. The same persons assured me, that having obtained of Dr. *Harbersfeld* a good quantity of his specifick, they had been (in *England*, as well as elsewhere) partly eye-witnesses, and partly performers of wonderful cures, by the help of it alone under God, in the king's-evil. Insomuch that an eminent gentleman of this nation, now alive and healthy, hath been cured by it, when the king's-evil had brought his arm to that pass, that the chirurgion had appointed a time to cut it off. And with the same liquor, only taken inwardly, they profess themselves to have seen and done divers cures of inveterate external ulcers, whose proud flesh, upon the taking of it is wont to fall off, and then the ulcer begins to heal at the bottom; but of the recent effects of this liquor, we may elsewhere, perhaps, further entertain you. That suffusions or cataracts may, by a mutual operation, be cured even in a patient, that was born with them, I formerly told you, when I related the cure done by my ingenious acquaintance, Mr. *Stepkins*, on a gentlewoman of about eighteen years of age, that brought a couple of cataracts with her into the world. And I remember, I was some while since in the company of another woman, who told me, that she was brought to bed of five children (if I much mistake not the number) successively; of which she saw not any in a long while after, by reason of a couple of suffusions, that had many years blinded her; and yet now, by the help of a Dutch oculist of my acquaintance, she sees, and reads well, and hath freely enjoyed the restored use of her eyes for some years already.

Examples
of cures of
cancers.

An example
of the cure
of one, that
was born
with a ca-
taract in
the eye.
And other
examples of
cataracts
strangely
cured.

BUT these are rather chirurgical, than medicinal cures; and therefore we shall subjoin the mention of a very memorable observation of the learned *Petronius*, which being collated

Alexand.
Trajan.
Petronius,
lib. 5. De
morb. Gal-
lico, c. 1. a-
pud Schenck-
ium in ob-
serv. l. 1.

collated with that a little above recited from Dr. Harvey, they may serve to keep each other from passing for incredible: *Quidam* (says our author) *qui antequam morbo Gallico afficeretur, altero oculo cæcus erat, suffusione densissima (vulgus cataractam vocat) oculum occupante, hydrargyri inunctione à morbo Gallico, et à suffusione, quod maximè mirum est, evasit. Neque à ratione alienum est inunctione illa cataractas posse dissolvi, cum frequens experientia doceat præduros tumores ex pituita crassa & concreta genitos, illitu hydrargyri potenter dissolvi.* ‘One, who before he fell into the French pox was blind of a cataract ‘in one of his eyes by being anointed with quick-silver, was recovered, not only from ‘the chief disease, but (which was most strange) from his cataract. Nor is it irrational, that cataracts should be dissolved by such anointing; when experience teacheth, ‘that hard tumours clogged together of pituitous matter are powerfully dissolved by ‘mercurial inunctions.’

Examples
of the cure
of the drop-
sy and gout.

I NEED not tell you what sad prognosticks physicians are wont to make of dropfies, especially of that sort, which they call *Ascites*. And indeed the event does but too frequently justify their predictions, when none but ordinary remedies are employed. But I remember, that being acquainted with an ingenious person, that was very happily cured of a dropfy, and inquiring who it was, that had performed the cure; I was informed, that that, and a multitude of the like, had been wrought by a German physician, of whom, and of his remedy, I had heard much commendation in *Holland*, where he lived. And though on divers occasions I found him a modest man, and accordingly, when I asked him concerning his cures of the dropfy, he answered me, that he neither did, nor would undertake to cure so formidable a disease; yet he scrupled not to tell me, that as far as he had hitherto tried, he had one remedy, which had not failed him, though he had tried it upon persons of differing ages, sexes, and complexions. But of this specifick more hereafter. For, at present, I must proceed to take notice, that as incurable a disease, as the radicated gout is thought to be, (especially in patients not very temperate;) and as tedious a course of physick, as one would expect to be requisite to the cure of it, in case it can be cured; yet I have been several times visited by an honest merchant of *Amsterdam*, who was there noted for his wealth, and his skill in *arte tinctoria*. This man, ten or twelve years ago, had been for a long time so tormented with the gout, both in hands and feet, that his fits would sometimes vex and confine him for a great part of the year, and not leave him without hard knots, as unwelcome pledges of their return: but once, that he was tortured to a degree, that made him much pitied, one came and informed him of an empirick, who had received from a great chymist, who had lodged in his house, a secret, with which he had already thoroughly cured many in a short time: whereupon sending for this person, and offering him any thing for some relief, the other refused to take above ten crowns, which, as it seems, was the usual rate for the cure, and would not receive that neither, until the reality of it had been evinced by the patient’s continuing about six months well. And accordingly, with a very few doses of a certain powder and tincture, the merchant was quickly freed, not only from his pains, but from his gouty tophy. And though he indulged himself the drinking of Rhenish wine very freely, yet he never had a fit since, as himself assured me one morning, wherein, for exercise sake, he walked five or six miles to give me a visit; adding, that the man that cured him, dying suddenly, never could discover what the secret was, wherewith so many had been freed from a disease, that does so often mock the skill of the greatest doctors.

I MIGHT, perhaps, if I had leisure, relate to you some other strange stories, which may invite you to think, that as the naturalist’s skill in chymistry, and other arts retaining to physiology, may much assist him to discover more generous remedies, than are yet usual; so the knowledge of such remedies may, in divers cases, make a happy change

change in the rules of prognosticating, what will prove the course and event of a sickness. But I shall not, at present, particularly consider any more than one disease, namely, the stone in the bladder. For whereas it is by most, even of the judicious physicians, unanimously pronounced incurable by physick in what person soever, if it deserve the name of a stone, and be too big to be voided whole, the remedilessness of this disease may be justly questioned. I remember the famous *Monardes*, treating of the seed of a Peruvian plant, which they call *Chalchoos*, tells us, that it is highly esteemed by the inhabitants of the country it grows in, and affirmed not only to be diuretick, and to bring away gravel, but to break the stone in the bladder itself, if it be not too much hardened: *Ejusque rei* (adds he) *tam multa proferunt exempla, ut admirationem mihi pariat*: ‘ And they urge many instances of it even to my admiration.’ He tells us indeed, that he is of opinion, that nothing but section can cure the stone of the bladder: *Aiunt tamen*, saith he, *illius semen* (of the *Chalchoos*) *tritum, ex aqua aliqua ad eam rem idoneâ sumptum, calculum in lutum dissolvere, quod excretum denuo concrevit, & in lapideam duritiem convertitur. Adolescentem vidi, cui hoc obtigisse scio; is cum vesicæ calculo torqueretur, idque à lithotomis, qui calculum deprebenderant, intellexissem, & ex symptomatis quæ patiebatur agnoscerem; hominem, veris initio, ad fontem, qui à Petro nomen habet, ablegavi, ubi cum duos menses hæssset, à calculo liberatus redit, & lutum omne, quod paulatim ejecerat, denuo in lapidum fragmenta concretum in charta secum retulit.* ‘ Yet they say, that the seed of the *Chalchoos*, ground and taken in any proper water, doth dissolve the stone into a very dirt, which being voided, doth harden again into a stony substance. I saw a young man, to whom (upon my knowledge) this accident befel. When he was tormented with the stone in the bladder, which I understood both by the lithotomist who felt it, and by the symptoms which he suffered; I sent him to a fountain, which takes its name from *St. Peter*: when he had staid there two months, he returned free from the stone, and brought home with him all the dirt, which he had voided by degrees, in a paper, coagulated as it were into fragments of stone.’ Which passage, I wonder such a writer should immediately annex to the declaration of an opinion, that must appear confuted by it, to a reader, that considers not so much what is thought, as what is proved.

Examples
of the cure
of the stone.

THE very learned and experienced Dr. *Gerard Boot*, of whose skill you, *Pyrophilus*, have found very good effect in your self, and who was one of the two professors, that writ the *Philosophia naturalis reformata*, had a very famous remedy (which now he is dead, I intend, God willing, to communicate) against the stone; and with it he told me, that he had very often cured that disease in the kidneys: but for the stone in the bladder, he thought it impossible to be dissolved; which circumstances I recite, that you may the more readily believe what he told me a little before his death; namely, that he had cured lately one Mr. *Moulin* of a real stone in the bladder; adding, that he could not brag of being the inventor of that remedy he had employed, having but lately learned it of a country gentleman, whom going to visit last summer, he saw a load of *Perficaria*, or arsmart, brought to him by some of the country people; and desiring to know what he intended to do with so vast a quantity of it, the gentleman replied, that he yearly used as much, having by the water of it, made by bare distillation in a common rose-water still, cured so many of the stone, even in the bladder, that he was usually solicited by patients, numerous enough, to exhaust all the liquor which he yearly prepared.

The use of
Perficaria
for that
cure.

WHAT we, *Pyrophilus*, have observed concerning this excellent liquor, of which we use to prescribe a draught every morning for some months together, we may elsewhere have occasion to relate. But now we shall go on to tell you, that being some years since in *Ireland*, I met with an ancient empirick, who was very famous in those parts
for.

for cutting of the stone of the bladder, and for curing sore eyes. This man having given (in the parts where I then was, and whilst I was there) some good proof of his skill, I sent for him to me, upon the account of a suspicion I long had of the stone in the bladder; which, upon search, he assured me I was free from, and so (God be praised) I have afterwards found it. He was more a traveller than a scholar, and yet finding him, to my wonder, very modest and sober, I inquired of him, whether he had never any where met with a remedy, that could dissolve the stone in the bladder, offering him much more for a cure of that kind, than he would require as a lithotomist. He answered me, that he could cure no man of a confirmed stone, but by the help of his knife; but if the stone consisted of a lump of gravel not very firmly cemented together, he had, by a certain inward remedy he used, and a dextrous way of crushing the stone from without with his fingers, so broken the stone, partly by crumbling it, and partly by dissolving the cement, as to make it avoidable by urine. And he added, that he had formerly cured a citizen of *Cork*, of a good large stone of the bladder, (for where I then was, he gave a proof of his skill, in telling before-hand those he was to cut, the bigness and shape of the stones, that troubled them.)

Instances in
other happy
medicines
for the same
disease.

De lith. c.
2. num. 14.

PASSING afterwards by *Cork*, I sent an intelligent servant to inquire after this citizen; but, he being casually absent, his wife sent me, by my man, a relation very agreeable to that, which he had made me. The receipt I purchased of him, and though it seem not very artificial, yet I suppose you will not quarrel with me, for annexing so experienced a one, to the end of this essay. But because this remedy needed the assistance of a manual operation, we shall further proceed to tell you, that *Cardan*, as he is quoted by *Helmont* (for I have not now his works by me) relates, that in his time there rambled a man over *Lombardy*, who did commonly, and in a few days, by a certain liquor which he administered to his patients, safely, speedily, and certainly cure those, that were troubled with the stone in the bladder: adding (saith *Helmont*) his judgment, that he doubted not of this man's being in hell, for having, when he died, envied mortals so excellent an art.

The use and
success of
millepedes.

I INSIST not on the testimony, that the same *Helmont* gives to *Paracelsus* of his curing the stone, though he often handle him very severely in other places of his writings, because that the epitaph of *Paracelsus* (out of which he labours to prove his having cured the stone) makes no express mention of it. Nor shall I enumerate those passages, from whence the same *Helmont's* followers collect, that he himself was able to cure that disease, by the resolution of *Paracelsus* his *Ludus*; but this experience hath evinced to me, that a much slighter preparation of that stone, than was mentioned by *Paracelsus* and *Helmont*, hath been able to do more in that disease, than a wary man would readily believe. But to detain you no longer on this subject, I shall only add, that *Wilhelmus Laurebergius*, a learned physician, and professor at *Rostock*, hath told the world, how he cured himself of a confirmed stone of the bladder, by the use of prepared millepedes (by some in *England* called wood-lice) and other remedies, which he hath particularly recorded in the history, which he hath published, and I have seen of this admirable cure; which having been epitomized by *Sennertus*, and other eminent physicians, I shall not need to insist on it. And the arguments alledged (even by the most judicious) against the curableness of the stone, though very plausible, seem not to me unanswerable; for whereas first they appeal to the innumerable fruitless attempts, that have been made to cure great princes, and rich men, without cutting, that argument drawn from experience may, by the former experiments, be answered, especially since *Horatius Augenius* (upon whose account *Laurebergius* tried millepedes) tells us, not only that he cured a young man at *Rome*, that was going to be cut of the stone, but that the Jesuit, that chanced to confess this youth, and persuaded him to the use
of

of millepedes, had experimented their efficacy both upon himself and others. And indeed we ourselves have found them to be highly diuretick and aperitive.

AND whereas it is next objected, that medicines must necessarily lose their efficacy before they can reach the bladder, I confess, that for the most part, it is very true; but yet that it is possible for some medicines to retain their nature, after many alterations and digestions, we have elsewhere declared. And in our present case, we not only find, that turpentine and asparagus do manifestly affect the urine (as I have often observed in my own, and almost any man may observe it in his;) but that which is most to our purpose, rhubarb tinges the urine of those, that have taken any quantity of it. And lastly, whereas it may be yet further alledged, that not only there hath not been yet a liquor found capable of dissolving so solid a body as a stone; but, if there were, it must necessarily be so corrosive as to destroy the patient, by fretting his stomach, or guts, or bladder, which are parts so much more tender: to the first part of this plausible objection it may be replied, that even good vinegar will dissolve not only those stony concretions, called *lapides cancrorum*, which, like the *calculi* we treat of, are formed in the bodies of animals, but even the more hard and solid body of coral, which will lose but little of its weight, in a fire, that would waste a great part of the *Duelech*: and that the bare juices of vegetables (such as lemons and barberries) will readily dissolve both pearl and coral, is known even to the apothecaries boys. Indeed, what *Paracelsus* and *Helmont* relate of their alkahest, with which they prepare their specifick against the stone, and with which the latter of them, if not both, pretend to be able to reduce, not only the stone they call *ludus*, but all other stones, vegetables, minerals, animals, &c. into insipid water, is so strange (not to say incredible) that their followers must pardon me, if I be not forward to believe such unlikely things, till sufficient experience hath convinced me of their truth.

The argument, concerning the incurableness of the stone, answered.

BUT yet I must not conceal from you, that a chymist, whom you have often seen, advised with me several times about the way of preparing this immortal liquor, (as *Helmont* calls it) and that, when we had agreed, that such a way was the most promising, he prosecuted it so long, and so industriously, that at length he obtained, and shewed me a liquor, which (though it seemed to me far short of the alkahest) I confess I admired; and not I alone, but our ingenious friend Dr. C. (who had been employed into several parts of *Europe*, by a rich and curious princess, to purchase rarities) agreed with this chymist, to give two hundred crowns for a pint of this menstruum; and confessed to me withal, that he saw him, with this liquor, not only dissolve common sulphur, and bring it over the helm, but reduce antimony into sweet crystals: with a few of which it was, that he (I mean Dr. C.) to the wonder of many, did, without purge or vomit, cure our good friend Sir C. C. of a very radicated and desperate disease, as the restored patient soon after told me. And to the second part of this objection it may be answered, that if we knew and considered well, how many of the operations of natural bodies depend upon the suitableness and difference of the figures of their parts, and the pores intercepted between them, the number of impossibilities would not, perhaps, be thought so great, as by many learned men it is.

THAT it is very possible for a body to have an effect upon another determinate body, without being able to operate in like manner upon a multitude of other bodies, which may seem more easy to be wrought on by it; may appear by the loadstone, which will draw and work only upon iron, and (which is but refined iron) steel, but not upon wood, or straws, or any of those innumerable concretes, that are lighter, and of a more open texture, than the heavy and solid body, which it attracts. And to give you an instance, that comes nearer to our case, quicksilver, that will not corrode our skin, nor so much as taste sharp upon our tongue, will yet readily dissolve that most compact

That there may be a liquor able to dissolve the stone, that may not be corrosive to any other part.

body of gold, which even aqua fortis, that can insinuate it self into all other metals, and corrode them, will not meddle with; though the same quicksilver will not dissolve iron, which yet aqua fortis will very nimbly fret asunder. So that, although I dare not confidently believe all, that I have found averred, even by eminent and learned chymists, of their having made or seen liquors, which, without appearing any way sharp to the tongue, would dissolve gold and silver, and other hard compact bodies; because I have not yet my self seen any severe and satisfactory trial made to evince the efficacy of insipid dissolvents: yet, by reason of divers things I have read and heard, and of some things too I have seen, I dare not peremptorily deny the possibility of such menstruums. And who knows, but that in nature there may be found, or by art there may be prepared, some liquor, whose parts may have such a suitableness to the pores of a human *calculus*, as those of quicksilver have to the pores of gold; and yet may as little work upon the rest of the body, as we have observed the same quicksilver to do upon iron, (which yet is a much more porous and open metal) even when it hath been distilled in iron vessels? And as to that part of the objection, wherein the strength of it chiefly lies, let me tell you, *Pyrophilus*, that I have sometimes, for curiosity's sake, taken an egg, and steeped it in strong vinegar for some days, and by taking it out, and shewing, that the shell was so eaten away, that the egg could be squeezed into unusual forms, but the thin skin, that involves the white, continued altogether unfretted, I convinced an ingenious man, that the operation of dissolvents are so determined by the various textures of bodies, on which they are employed, that a liquor, which is capable to corrode a more hard and solid body, may be unable to fret in the least another more soft and thin, if of a texture indisposed to admit the small parts of the menstruum. And I must confess to you, *Pyrophilus*, that one thing, among others, which hath made me backward to affirm with many learned men, that there can be no potent dissolvent, that is not corrosive enough to fret in pieces the parts of a human body, hath been a story, which I divers years since, chanced to meet with in the learned *Sennertus's Paralipomena*, where, though he relates it to another purpose, yet it is so pertinent to our present design, and in it self so singular, not to say matchless, that I cannot forbear to mention it here on this occasion. He tells us then, that in the end of the year 1632, *Johannes Nesterus*, an eminent physician, and his great friend, informed him, that there lived at that time in the neighbourhood, and belonging to a nobleman of those parts, a certain Lorrainer, whom he also called *Claudius*, somewhat low and slender, and about 58 years of age: *Hic* (saith he) *nihil fatidum, nihil injucundum abhorret; vitra, lapides, ligna, carbones, ossa, leporinos & aliorum animalium pedes cum pilis, lineos, laneosque pannos, viva animalia, & pisces adhuc salientes, imò etiam metalla, patinas & orbes stanneos dentibus confringere & vorare sæpissimè visus est. Vorat præterea lutum, serum & candelas sebaceas, integras testes cochlearum, animalium stercorea, cum primis bubulum calidum adhuc, prout è matre venit: potat aliorum urinas cum vino & cerevisia mixtas. Vorat fœnum, stramen, stipulas, & nuper duos mures viventes adhuc deglutivit, qui ipsius ventriculum ad semiboram usque creberrimis morsibus lancinarunt; & ut brevibus complectar, quicquid illi à nobilibus devorandum offertur, vilissimâ mercede propositâ, dictum ac factum, ingurgitat, ita ut intra paucos dies integrum vitulum crudum & incoctum cum corio, & pilis se estaturum promiserit. Testes inter alios quamplurimos ipse ego sum, quippe qui, &c.*

“ He loaths nothing that stinks, or is otherwise unpleasant. He hath been often seen
 “ to chew and swallow glass, stones, wood, bones, the feet of hares, and other animals,
 “ together with the hair; linen, and woollen cloth; fishes, and other animals alive;
 “ nay, even metals, and dishes, and globes of tin: besides which, he devours sewet,
 “ and tallow-candles, the shells of cockles, and the dungs of animals, especially of
 “ oxen, even hot, as soon as it is voided. He drinks the urine of others mixt with
 “ wine

Examples
of those,
who could
digest me-
tals and
glass.

Medicus
Rochlizen-
sis.

‘ wine or beer; he eats hay, straw, stubble, and lately he swallowed down two living mice, which for half an hour continued biting at the bottom of his stomach; and, to be short, whatsoever is offered him by any noble persons, it goes down with him without more ado upon the smallest reward, insomuch that within a few days he hath promised to eat a whole calf raw, together with the skin and hair. Among divers others, I my self am a witness of the truth of these, &c.’ To this and the following part of the letter, *Sennertus* adds, that not having, during some years, heard any thing concerning this *Claudius*, he sent about four years after to the same physician, *Dr. Nesterus*, to enquire what was become of him; and that the doctor sent him back a letter of the minister of the church of that place, by way of confirmation of all the formerly mentioned particulars, and answered himself, that the Lorrainer, whom he had long hoped to dissect, was yet alive, and did yet devour all the things mentioned in his former letter, but not so frequently as before; his teeth being grown somewhat blunter by age, that he was no longer able to break bones and metals. Some other examples of this nature, though none so strange, we have also met with in writers of good credit, and especially that of the glass-eater, recorded by *Columbus* in his excellent anatomical observations; of which also *Sennertus* makes mention, as we shall see by and by, and with which we may elsewhere entertain you to another purpose. And not long ago there was here in *England*, a private soldier (who, for aught I know, is yet alive) very famous for digesting of stones. And a very inquisitive man, that gave me the accuratest account I have met with concerning him, assures me, that he knew him familiarly, and had the curiosity to keep in his company for twenty-four hours together to watch him, and not only observed, that he eat nothing in that time, save stones (or fragments of them) of a pretty bigness, but that his gross excrement consisted chiefly of a sandy substance, as if the devoured stones had been in his body dissolved and crumbled into sand. But let us not omit, that to the second epistle above mentioned *Sennertus* adds this reflection, not impertinent to our purpose: *Causam* (says he) *kujus voracitatis, etiam in cadavere, invenire proculdubio erit difficillimum. Posset quidem ad illud, quod in cadavere Lazari vitrivoracis observavit Columbus, quidam confugere; & statuere quartam illam nervorum conjugationem, quæ gustus gratia in hominibus à natura producta est; neque ad palatum, neque ad linguam pertendere. Verum hoc modo saltem gustus aboliti causa redderetur, nondum verò causa daretur; cur res tam miras assumere sine ventriculi læsione, imò concoquere potuerit. Quæ proculdubio in ιδιοσυγκρασία & peculiari constitutione ventriculi & intestinorum querenda esset; quæ tamen oculis investigari non potest, sed saltem ex effectu patet: ‘ To find in the carcass the cause of this voracity, will be, questionless, very difficult. Some one perchance would refer it to that, which *Columbus* observed in the carcass of *Lazarus* the glass-eater, and resolve, that the fourth conjugation of nerves, which nature ordained for tasting, comes neither to the palate, nor the tongue: but so there would only be rendered the cause of this want of taste, and not why he should be able to take such uncouth things, without offence to his stomach, and digest them, which without doubt ought to be the particular and singular constitution of his stomach and guts, which yet may not appear to the eye by the effects.’ And indeed this memorable story seems to argue, not only what we have already alledged it to prove, but also that a menstruum not so corrosive as to fret the body, may dissolve stones, metals, and other compact substances. And since one liquor, prepared by nature only, could in this man’s stomach dissolve that great variety of bodies above enumerated, why should it be thought, that the alkalest, or some other menstruum, wherein nature is skilfully assisted, and to the utmost heightened by art, should not be able to dissolve concretes of very differing textures? For though chymists must acknowledge, that such common menstrua, as will dissolve one body, will not often-*

times meddle with another; as aqua fortis will dissolve silver, and not gold; and if by sal armoniac you turn it into aqua regis, it will indeed dissolve gold, but then it will not silver: yet since that may be supposed to proceed rather from our want of skill to prepare the most potent menstruum, than from the impossibility of one menstruum's dissolving great variety of bodies; why may not nature and art afford a menstruum, whose variety of parts and figures, and, perhaps also, motion may give it ingress into bodies of very differing textures? as in our former instance, though aqua regalis will dissolve gold, not silver, and aqua fortis silver, but not gold, yet quicksilver will dissolve both, and copper, tin, and lead to boot.

The description of a menstruum, prepared from a common bread, able to draw tinctures from precious stones, minerals, &c.

If I were not at present under some restraint, I might tell you some things, that you would, perhaps, think no weak confirmations of the past discourse. And however, since I have observed it to be the main thing, that keeps judicious men from seeking, or so much as hoping for nobler dissolvents, that they are scarce to be persuaded there can be considerably piercing menstrua, that are not so proportionably corrosive; I will here acquaint you with a liquor, that may, I presume, assist you to undeceive some of them. We take then ordinary household brown bread (I like that of rye, but I have divers times used that of wheat) and when it is cut into slices, and somewhat dried, we almost fill a glass retort with it, and placing that in a sand-furnace, by degrees of fire we draw off what will be made to come over, without much difficulty. The oil, as useless to our purpose, being by a tunnel, or a filter, severed from the rest of the liquor, we also, by a gentle heat, free the spirit from some of its phlegm, which yet sometimes we find no great necessity to do. And yet this spirit, which you will easily believe is no such corrosive as aqua fortis, or other distilled liquors of mineral salts, will work upon the hardest sorts of bodies, and perform things that chymists, counted of the judiciousest, would not have us expect from the most sharp and corrosive menstrua now in use. For with this we have, in a short time, and that in the cold, drawn tinctures (which is done by the solution of the finer parts of the concrete) not only from crude corals, and some of the more open minerals, but likewise from very hard stones, such as blood-stone, and granates, (even unpowdered.) Nay, and though rubies seem to be the hardest bodies yet known save diamonds, (for I have learned from those, that cut precious stones, that they can grind other gems with the powder of rubies, but not these with any powder, save their own, and that of diamonds;) yet have even these afforded me, in the cold, a not ignoble tincture. And not to anticipate what I may elsewhere have occasion to tell you concerning the efficacy of this menstruum, which is the same, that I have intimated, without naming it, in the last and another of the former essays; I shall now only add, that an expert chymist assures me he hath, but tells me not how, done greater matters with it, or the like; and that to satisfy my self, that these high tinctures proceeded not from the standing or digestion of the menstruum (as we elsewhere observe concerning some other liquors) I not only tried, that from some minerals it will draw a much higher tincture than from others, and from some scarce any at all; but that it would, if kept by it self, for many months continue clear and limpid. What further use I have made, or think others may make of this odd menstruum, I must not, as I said, at present express; but returning to what I was discoursing concerning the cure of the stone, annex, that besides what hath been objected against the possibility of making a liquor, which, without being highly corrosive, can be able to work upon stone; it may indeed be also alledged against the hopes we seem to countenance, that what hath cured the stone in one man's bladder, may be unable to do the like in another's. But first, the truth of that hath not been proved; and next, we highly value those specifics, that can remove agues, fluxes, and the like diseases; though scarce any of them do alike succeed in all patients, especially

especially so as to secure them during their whole lives, from ever relapsing into the like disease; and besides all this, it will be no small matter to find, that the disease, in its own nature, is not incurable; and it would recompense men's industry to be able to free, even a few patients, from so painful and stubborn a disease. Which I have, rather than any other, chosen to insist upon, because it is so generally believed not to be curable by inward remedies in any person whatever.

BUT I have entertained you so long on this subject, that I must reserve, for some other opportunity, what I have to say to you concerning the dropsy, and some other diseases, commonly put into the catalogue of the incurable ones; and therefore shall now only tell you in general, that as on the one side I think the arguments, which *Helmont* and others draw from the providence of God, for the curableness of all diseases, are not very cogent, and somewhat irreverent, (for God being not obliged any more to continue life or health to sinful man, than to beasts, that never offended him, we ought humbly to thank him, if he hath, among his creatures, dispersed remedies for every disease, but have no right to accuse him if he have not;) so on the other side, I am not much convinced by the grand argument alledged against *Paracelsus*, and the chymists, that hold all diseases to be in their own nature curable, namely, that they themselves many of them, (no nor even their very master) lived not to the age attained by many strangers to chymistry.

Helmont's argument from the providence of God censured.

FOR this, that many of them (not destroyed by war, or outward accidents) died young enough, and consequently by sickness, and that *Paracelsus* himself out-lived not the 47th year of his age, is a much stronger objection against the men, than against their opinion; for it infers indeed plausibly, that they had not such remedies as they boasted of, (since probably, had they had any such, they would have cured themselves with them;) but concludes not, that no such remedies can be prepared by any other. And this you will be less apt to think irrational, if you consider, how much more learned, sober, and experienced it is possible for many a man to be, than *Paracelsus* appears to have been. For he seems not, by his writings, to have been any great logician or reasoner; he manifestly despised many parts of learning useful to a physician; he lived not many years, and spent divers of those few, which he lived, in an unsettled and disadvantageous course of life; and yet this *Paracelsus* attained to some such remedies, as both in his own and after-times have made him a very considerable person, in spite of all his indiscretions and deficiencies. And among his other remedies, his famous *laudanum* did such wonders, that *Oporinus* himself, in that short account, which seems to be rather a satire than a narrative of his life, hath this passage of it: *De laudano* (saith he) *suo (ita vocabat pilulas instar murium stercoris, quas impari semper numero, in extrema tantum morborum difficultate tanquam sacram medicinam exhibebat) ita gloriebatur, ut non dubitavit affirmare ejus solius usu se à mortuis vivos reddere posse; idque aliquoties, dum apud ipsum fui, re ipsa declaravit:* 'Of his *laudanum* (that name he gave to little pills, which in the extremity of diseases he administered as a most divine medicine, always giving them in an odd number) he scrupled not to affirm, that by that medicine he could put life into those, who were as good as dead; and that while I was with him, he made good in some experiments.' So signal a testimony coming from one, whom the Paracelsians call his fugitive servant, hired by his enemies to slander him under pretence of writing his life, deserves not to be slighted: and though it manifestly contains an hyperbole, yet I do the less wonder at the hyperbole, by reason of those strange things, which your mother, and divers other of your friends, can tell you, they have seen performed in England by *Helmont's laudanum opiatum*, (though much inferior to that of *Paracelsus*.) And I remember, that a friend of yours and mine, that is a great enemy to all kinds of chymical remedies, and was before also to chymistry,

The argument, that *Paracelsus* out-lived not the 47th year of his age, answered.

The efficacy of *Paracelsus's laudanum*.

mistry, having begged of me a little bottle of it, which I had obtained from a friend of the younger *Helmont's*, to whom he communicated the preparation, gave me a while after an account of such cures, that had been performed, with that small quantity, upon almost dying persons, as I think it not discreet for me, that was not an eye-witness of them, to relate. And I remember too, that the same friend of young *Helmont's*, being, at the persuasion of one woman, whom he had cured of a dangerous consumption, called to another, that was thought to be dying of an asthma, came to advise with me, whether he should meddle with so desperate a patient; telling me, that she had been many years sick of that stubborn disease, which, in process of time, passing into an orthopnea, had at last put her, by want of sleep (from which the violence of her sickness had very long kept her) into a fever, and so desperate a condition, that it was scarce expected she should live till the next morning. But I representing to him, that her condition being avowedly desperate, he might exercise his charity without danger to his reputation; and persuading him to try *Helmont's laudanum*, together with the spirit of man's blood (which we elsewhere teach you to prepare) he gave her that night a dose of those remedies, which made her both sleep and breathe pretty freely; and a week after, he coming to visit me, told me, he had casually met his patient well and abroad in the streets. But these are trifles to the cures, which *Helmont* relates to have been performed by our Irish *Butler*: for he tells us, that this man, by slightly plunging a little stone, he had, into almond-milk or oil, imbued those liquors with such a sanative efficacy, that a spoonful of the former cured (and that without acquainting him with what was given him) a Franciscan frier (a very famous preacher) of a very dangerous erysipelas in the arm, in one hour; and one drop of the latter being applied in his presence, to the head of an old laundress, that had been sixteen years troubled with an intolerable hemicrania, the woman was presently cured, and remained so to his knowledge for divers years. He adds almost as strange a cure done in one night, upon a maid of his wife's, by anointing the part affected with four drops of that oil. He farther tells us, that the master of the glass-house at *Antwerp*, being troubled and made unwieldy with too much fat, begged some relief of *Butler*; who, having given him a little fragment of his little stone, with order to lick it nimbly with the tip of his tongue once every morning, I saw, saith *Helmont*, within three weeks, the compass of his waist lessened by a span, without any prejudice to his health. And to these, *Pyrophilus*, he adds some other narratives, which, though I confess I know not well how to believe, yet there are circumstances, which keep me from daring to reject them. For first, as he well observes, that, which was most stupendous in this remedy, was but the smallness of the quantity. Next, a gentleman in *France* being not long since reported to have a fragment of this stone, and to have cured several persons (and especially one very dignified) of inveterate diseases, by letting them lick it; my noble friend Sir *Kennelm Digby*, then in *France*, was solemnly requested from hence to inquire into the truth of that report, and answered, that he could not, upon examination, find it other than true. Besides, *Helmont* not only relates these cures as an eye-witness of them, but tells us, how upon an occasion, that he mentions, he once suspected the efficacy of the oil; and that, without expecting, that it should do any thing, he anointed it on the right arm and the ancles of his own wife, who had for some months been tormented with great pains in the former, and very great tumours in the latter of those parts; and that, almost in a trice, motion was restored to her arm, and all the *oedema* of her legs and feet vanished; adding, that at the time of his writing she lived healthfully, and had done so since that recovery, during nineteen years. And this story she, long after her husband's death, confirmed to our ingenious friend Dr. C. who is acquainted with her, and much extols her. These circumstances may be assisted by two more very considerable

Butler's
great remedies.

Helmont in
the treatise,
which he
entitles
Butler.

considerable ones; the one is, that *Helmont* is the more to be credited in these relations, because mentioning cures not performed by himself, but by others, and that by remedies unknown to him, he seems by these narrations, out of loyalty to truth, to eclipse his own reputation: and the other is, that in a memorable story, which we may elsewhere relate to you (being not here proper to insert so long a one) you'll find an eminent and strange testimony given to *Butler's* secrets, by our famous countryman *Dr. Higgins*, whose confession you will not doubt, if you consider how rare a physician and chymist he was, how familiarly he lived in the same house with *Butler*, and how studiously at last they endeavoured to take away each other's life.

BUT whatever be to be thought, *Pyrophilus*, of *Helmont's* relation, we may well enough make this reflection on the other things, that have been delivered concerning formidable diseases, that since the power of nature and skill may reach much farther than many distrustful (not to say lazy) men have imagined, it will not be charitable to rely too much upon the prognosticks, even of famous writers, when they tell us, that such and such diseases, or patients in such and such conditions cannot possibly be cured: but rather to follow the sober counsel of *Celsus*, *Oportet* (saith he) *ubi aliquid non respondet, non tanti putare auctorem quanti agrum, & experiri aliud atque aliud.* 'Where a medicine answers not, we ought not so much to esteem the author as the patient, and to try somewhat farther and farther.' And this great physician's authority I therefore make the most use of in the ensuing essays, because he is accounted very judicious by the Lord *Verulam*, and other writers, that are unquestionably so themselves.

De medici-
na, lib. 3.
cap. 10.

ESSAY IV.

Presenting some things relating to the Hygieinal part of Physick.

THAT the dietetical part of physick, *Pyrophilus*, may, as well as the others, be improved by natural philosophy, were not uneasy to manifest, if my haste would permit it: for it is known, that drinks make a very considerable part (sometimes, perchance, amounting almost to the one half) of our aliments; and most drinks, as wine, beer, ale, mead, &c. consist of fermented liquors. Now as on the one side the ignorance of the doctrine of fermentation, and of the wholesome way of both preserving liquors and making them pleasant, doth questionless occasion more than a few diseases, which in divers places may be observed evidently to proceed from the unwholesome quality of either ill-made or sophisticated drinks; so, on the other side, the distinct knowledge of the true nature and particular phenomena of fermentation would enable men to prepare a great variety of drinks, not only as harmless, but as beneficial as pleasant.

That the
knowledge
of fermenta-
tion is
useful to
make our
drinks
wholesome
for aliments.

How much preparation may do to correct and meliorate both hard and liquid aliments, is notably instanced by the account, that we receive from both the French and English that inhabit the *Barbados*, *St. Christophers*, and other *Carribee* islands, who solemnly inform us (what is attested also by *Piso*, and other learned travellers, that write of it) that the plant *mandioca* (whose prepared root makes cassavy, and which we have also seen flourishing here in *Europe*) to which the Indians are so much beholden, is a rank poison. And though I shall tell you, that having purposely inquired of a
I very

How much
simples may
be altered
by prepara-
tion, ex-
emplified by
the Indians
making Caf-
savi out of
the poison-
ous plant
Mandioca.
Odd un-
handsome
ways of
their mak-
ing drink
from the
same root.
History of
the Barba-
dos, pag. 29,
30, 31, 32.

very intelligent gentleman, who commanded an army of Europeans in *America*, what experience he had seen of the qualities of this plant, he told me, that between thirty and forty of his soldiers, having on a time (whilst they were unacquainted with the country) either through ignorance or curiosity, eaten of it unprepared, it cost most of them their lives. And yet this pernicious root, which some herbarists call *yucca*, by the rude Indians ordering, comes to afford them both almost all their bread, and no small part of their drink. For this root being grated, and carefully freed from its moisture, by being included in bags, and very strongly pressed, till all the juice be squeezed out, it is afterwards dried in the sun, and so made into meal, of which they make their bread. And this very root, though (as we said) it be poisonous, they cause their old and almost toothless women, for the better breaking and macerating it, to chew and spit out into water. This juice will, in a few hours, work and purge itself of the poisonous quality, affording them a drink which they esteem very wholesome, and at the *Barbados* call *perino*, and account it to be the likest in taste to our English beer, of any of those many drinks, that are used in that island.

THIS nasty way of preparing drink, *Pyrophilus*, may seem strange to you, as it did to me, when I first heard of it; but besides the consenting relations both of French and English concerning it, it may be confirmed by the strange assertion of *Gulielmus Piso*, in his new and curious *Medicina Brasiliensis*, where, having spoken of several of the Brazilian wines, he tells us, that they make liquors of several plants besides the root of mandioca, after the same nasty manner. *Idem fit* (saith he) *ex mandioca, patata, milio Turcico, oryza, & aliis, quæ à vetulis mastucantur, masticataque multa cum saliva expuntur; hic liquor mox vasis reconditur, donec ferveat, faecesque ejiciat.* 'The same is made of mandioca, potatoe's, Turkish millet, rice, and other things, which being chewed by old women, and spit together with much spittle, this liquor is strait put up into vessels, and there kept, until it ferments and casts down a sediment.'

Voyage de
Muscovie
& de Perse,
p. m. 23.

IN *Muscovia* itself, notwithstanding the unskilfulness of that rude people, *Olearius* informs us, that the embassadors, to whom he was secretary, were presented at one time with two and twenty several sorts of drink. And at a country-house here in *England* (where I was, by a very ingenious gentleman, that is master of it, presented with divers rare drinks of his own making) I was assured, that he had lately, at one time in his house, at least the former mentioned number of various drinks, and might easily have had a greater, if he had pleased.

Of making
drink from
sorts of
coarse
bread.

AND on this occasion, I am not willing to pretermitt what is practised in some of our American plantations, as I am informed by the practisers themselves; where, finding it very difficult to make good malt of maiz, or Indian corn, (by reason of hindrances not to be discoursed of in few words) they brew very good drink of it, by first bringing the grain to bread; in which operation, the grain being both reduced into small parts, and already somewhat fermented, is disposed to communicate easily its dissoluble and spirituous parts to the water it is boiled in. To which I shall add, that I have reason to think, that the art of malting may be much improved by new and skilfully contrived furnaces, and a rational management of the grain.

NOR are we alone defective in the knowledge of fermenting drinks, but even in that of the materials, of which drinks may be prepared.

The drinks
in use in
China.

History of
China,
part I. c. I.

IN that vast region of *China*, which is enriched with so fertile a soil, and comprizeth such variety of geographical parallels, they make not (as *Semedo* informs us) their wine of grapes, but of barley; and, in the northern parts, of rice, where they make it also of apples: but in the southern parts, of rice only; yet not of ordinary rice, but of a certain kind peculiar to them, which serves only to make this liquor, being used in divers manners. And of the wine there drank, even by the vulgar, our author gives,

us this character: The wine used by the common people, although it will make them drunk, is not very strong or lasting; it is made at all times of the year, but the best only in the winter: it hath a colour very pleasing to the sight, nor is the smell less pleasing to the scent, or the flavour thereof to the taste; take all together, it is a vehement occasion, that there never wants drunkards, &c. And of the inhabitants of the kingdom of *Japan*, I remember also, *Pyrophilus*, that *Linschoten*, in his description of those Islands, tells us, that they drink wine of rice, wherewith they drink themselves drunk.

Linschoten's
voyages,
book 1. c.
26.

WE have here in *England*, at the house of our experienced mint-master, *Dr. Gordon*, tasted a wine, which he made of that sort of cherries which are commonly called morrello, that was, when we drank of it, about a year and a half old, but it was somewhat sour, and needed fugar. And therefore I shall rather take notice to you of my having since drank wine made of the juice of good, but not of extraordinary Kentish cherries, which, with the help of a *tantillum* of fugar added in the fermentation, kept so well, that though it were above a year old when I tasted it, I found it a strong and pleasant wine, not inferior to many wines, that are brought us from foreign parts. But this is nothing to what is averred upon his own experience, by a learned divine (to whom you, *Pyrophilus*, and I, am related) who affirms himself to have made out of some sort of wild apples and pears, by bare fermentation, such liquors, as though at first somewhat harsh, will not only keep divers years, but, at the end of two or three, attain such strength, and so pleasingly pungent a taste, that they may compare even with choice outlandish wines, and excel those, that are not of the very best sorts of them.

Of cherry
wine.

Of excel-
lent cydeta.

BUT till we have in another essay an opportunity of presenting you something out of the observations of *Olearius*, the newly mentioned divine, and our own, concerning fermented liquors, we shall content our selves to manifest our want of curiosity about the materials, of which drinks may be prepared, by this, that the drinks of one whole country are oftentimes unknown to the inhabitants of another. That the wine made of rice, which we lately mentioned to be of frequent use in the kingdoms of *China* and *Japan*, is of little or none in *Europe*, I need not prove to you. I have been in divers places, where beer and ale, which are here the common drinks, are greater rarities than the medicated liquors sold only in apothecaries shops. In divers parts of *Muscovy*, and some other northern regions, the common drink is *hydromel*, made of water fermented with honey; and indeed, if a due proportion betwixt those two be observed, and the fermentation be skilfully ordered, there may be that way, as experience hath assured us, prepared such a liquor, both for clearness, strength, and wholesomeness, as few, that have not tasted such a one, would readily believe.

Of hydro-
mel.

THE French and English inhabitants of the *Caribbee* Islands, make, by fermentation, a wine of the dregs collected in the boiling of fugar. A like to which *Piso* tells us, that they make in *Brasil*, and commonly call *garapa*, which, though made by the mixture of water, the inhabitants are very greedy of; and when it is old, find it strong enough to make them drunk. And how also in these colder countries a good wine may be made of only fugar and water, we may elsewhere have occasion to teach you.

Of fugar
wines.
Lib. 4. c. 1.

AND in *Brasil* they likewise, as the same author informs us, make a wine (unknown to most other regions of the world) of the fruit of *acaju*, which yet, upon his experience, he much commends; telling us, that it is strong enough to inebriate, and may, he doubts not, be kept good many years; and that though it be astringent, yet both in himself and others he found it diuretical.

Lib. 4. c. 6.
Of other
Brazilian
and Barba-
dos wines.

IN the *Barbados* they have many drinks unknown to us; such as are *perino*, the plantane drink, *grippe*, punch, and the rare wine of pines, by some commended more than the poets do their nectar; some of which we therefore make not, because the vege-

tables, whereof they are produced, grow not in these colder climates: but others also they have, which we have not, though they are made of plants to be met with in our soil; as for instance, the drink they call *mobby*, made of potatoes fermented with water, which, being fit to drink in a very few days, and easy to make as strong almost as the maker pleaseth, would be of excellent use, if it were but as wholesome as it is accounted pleasant.

The way to
make wine
of raisins.

In the Turkish dominions, where wine, properly so called, is forbidden by *Mahomet's* law, the Jews and Christians keep in their taverns a vinous liquor made of fermented raisins, after a manner, which (when we shall elsewhere acquaint you with it) you will easily discern to be capable of much improvement from the knowledge of fermentation. And indeed by the bare fermenting of raisins and water, in a due proportion, without the help of barm, leaven, tartar, or other additament to set them a working, we have divers times, in a few days, prepared a good vinous liquor, which having for trial's sake distilled, it afforded us greater store than we expected, of inflammable spirit, like that of other wine.

Of wines
from the
dropping or
weeping of
wounded
vegetables.

BUT I have sometimes wondered, that men had no more curiosity to try what drinks may be made of the juices obtainable by wounding or cutting off the parts of several trees, and some other vegetables: for that in the *East-Indies* their *sura* is made of the liquor dropping from their wounded coco-trees, we have not long since out of *Linschoten* informed you. And sober eye-witnesses have assured us, that in those countries they have but too often seen the sea-men drunk, by the use of liquors weeping out of the incisions of wounded vegetables, and afterwards fermented.

De Manna,
cap. 13.

Of the
tears of the
walnut-
trees.

AND that even in *Europe*, the alimantal liquor, drawn by trees from the earth, may receive great alterations from them, before it be quite assimilated by them, may be gathered from the practice of the Calabrians and Apulians; who betwixt *March* and *November*, do by incisions obtain from the common ash-tree, and the *ornus* (which many botanists would have to be but a wild ash) a sweet juice, so like to the manna, adhering in that season to the leaves of those kind of trees, that the natives call it in their language, *manna del corpo*, or trunk manna. And lest we should think they draw all this sweetness from the soil of that particular part of *Italy*, where they grow, you may be satisfied by the learned *Chrysostomus Magnenus*, in his treatise *de Manna*, that it is to be met with in several other places. And he adds, that in the dukedom of *Milan*, where he professeth physick, there is no other manna used, than that, which is (as he speaks) *vel è trunco expressum* (which he somewhere calls *manna truncinum*) *aut in ramis striatim concretum*; and that yet it is safely and prosperously used.

The use of
the tears of
birch, with
some other
ingredients,
for the stone.

I HAD communicated to me, as a rarity, a secret of the king of *Poland's*, which is said to do wonders in many diseases, and consists only in the use of the liquor, which drops about the beginning of the spring from the bared and wounded roots of the walnut-tree: but because I have not yet made trial of it my self, I shall pass on to observe to you, that in some northern countries, and even in some parts of *England* bordering upon *Scotland*, the almost insipid liquor, that weeps in *March*, or the beginning of *April*, out of the transversely wounded branches (not trunks) of the birch-tree, is wont to be used by persons of quality as a preservative from the stone; against which cruel disease, *Helmont* highly extols a drink made of this liquor and *semen dauci* and *beccabunga*, and I think not without cause. For not to mention all the commendations, that have been given me of it by some that use it, I have seen such strange relief frequently given, among others, to a kinsman of mine, to whom hardly any other remedy (though he tried a scarce imaginable variety) was able to give ease, (and in whose diseased bladder, after another disease had killed him, a stone of many ounces was found) that I usually every spring take care to provide a quantity of this water, with which alone,

alone, without the other ingredients mentioned by *Helmont*, my kinsman used to be relieved as long as he could keep it; which you may do the longer, by pouring upon the top of it a quantity of fallad-oil, to defend it from the air; and perhaps also by distillation: by which (last named) way, I know an ingenious man, that is wont to preserve it for his own use, and says, he finds it not thereby impaired in virtue. But the most effectual way, that ever I yet practised, *Pyrophilus*, to preserve both this and other liquors and juices, is dextrously and sufficiently to impregnate them with fume of sulphur, which must be at divers and often times as it were, incorporated with the liquor by the due agitation; the manual operation belonging to this experiment, I may hereafter have occasion to describe more fully, together with the particular effects of it in several bodies. And therefore it may here suffice to tell you, that if you practise it carefully, you will, perhaps, think your self obliged to thank me for the discovery of it, though a heedful reader may find it, not obscurely, hinted in *Helmont's* writings.

The ways to preserve these liquors.

I MIGHT here annex the great commendation, which I have found given to this birch-water, by eminent writers, against the hot distempers of the liver, and divers other affections; and especially how *Freitagius* commends it very much to dilute wine with: and adds, *Hæc est dulcicida & grati saporis, sitim sedat, viscerum & sanguinis fervorem temperat, obstructions reserat, calculum pellit*: 'This birch-water hath a sweet sharpness, and very pleasant taste; it allays thirst, and the dryness of the entrails; it tempers the heat of the blood; it opens obstructions, and drives out the stone.'

The use of these tears of birch in hot distempers of the liver and hot catarrhs. In confilio medicinali in catarrho calido pro principe quodam.

BUT I suppose you will think it high time for me to proceed to another subject; and indeed I should not have spent so much time in discoursing of drinks, but that I am apt to think, that if there were greater variety of them made, and if they were more skilfully ordered, they might, by refreshing the spirits, and insensibly altering the mass of blood, prevent and cure (without weakening or much troubling the patient) almost as many diseases, as the use of our common, unwholesome and sophisticated wines is wont to produce.

FOR in fermentation, the sulphureous (as chymists call them) the active, and the spirituous parts of the vegetables, are much better loosened, and more intirely separated from the grosser and clogging parts, in most mixts, than they are by the vulgar ways of distillation, wherein the concrete is not opened by previous fermentation. And these nobler parts being incorporated with our aliments, are with them received freely, and without resistance carried into the mass of the blood, and therewith, by circulation, conveyed to the whole body, where their operation is requisite. And I remember, that discoursing one day with an eminently learned and experienced physician, of the antinephritical virtue of our common wild carrot-seed, fermented in small ale; he smilingly told me, that he found its efficacy but too great; for having prescribed it to some of his rich patients, who were wont frequently to have recourse to him in their nephritical distempers, after the use of this drink for a pretty while, he seldom heard of them any more. And for your encouragement, *Pyrophilus*, to make trials of this nature, we will add, that though the seed it self be not over-well tasted, yet being fermented in a due proportion with the liquor (we used an ounce and half of the seed, to a gallon of the ale) the drink composed of both tasted pleasantly, almost like lemmon-beer.

The use of daucus ale, and proportion of the seed to the liquor.

AND that you may the less wonder at the efficacy of fermented liquors, it is worth considering, what virtue is ascribed to the bare decoction of that herb, which the French and we call *Tbé* or *Tè*, which is much magnified here; and as far as my little experience in my self, and others (of which more hereafter) reaches, not altogether without cause: but among the Chinese and the Japonians, it is the common drink of persons of quality, by whom it is so highly praised, that the experienced *Tulpius*, in

OF Thé or Té.

Obs. lib. 4.
cap. ult.

the new edition of his *Observations*, tells us, that one pound of the Japonical *T'chia* (as the natives call it) is not unfrequently fold for one hundred pounds of silver; which is not to be wondered at, if they justly ascribe to it, that in those countries men are not subject to the stone, or the gout, and if but one half of the virtues he there attributes to it, be for the most part to be found in it.

Of animal
drinks.

I MIGHT, when I told you of the variety of materials not used among us, have added one strange drink, which a chirurgeon, that a while since lived at in the *East Indies*, told me, he saw much used thereabouts: they make it of the raw flesh of goats, capons, and the like, which together with rice and molosses (or black coarse sugar) they put into a quantity of water, and distil it in an alembick till the liquor be stronger than brandy, (as they call common weak spirit of wine, or of lees of vinous liquors) and this *rack* (as the extravagant liquor is called) is often drank in hot weather, and found very comfortable: those, that use it, prizing it much, as supposing it draws a nutritive and cherishing virtue from the flesh, as indeed, if any quantity of the nobler parts of that do concur to the constituting of the liquor, it may probably be, at least to divers bodies, very wholesome in that country, where they find strong drinks necessary to recruit their spirits, exhausted by the excessive heat of the climate. As I remember, the experienced *Bontius*, in his *Medicina Indorum*, tells us, that the merchants travelling through the scorching deserts of *Arabia*, *Persia*, or *Turkey*, find it best to quench their thirst by a draught of the spirit of wine, or else of the strongest Persian or Spanish wine.

Dialogo 3.

The use of
brandy or
wine in hot
climates.

AND of the great use, if not necessity, of either brandy, or such other strong and spirituous drinks in the hot climates of the *Indies*, divers intelligent persons of our own country have, upon their own experience, sufficiently satisfied us.

The use of
natural phi-
losophy to
meliorate
sacata.

NOR, *Pyrophilus*, is natural philosophy able only to improve our drinks, but the rest of our aliments also: for not to mention, that experience hath assured us, that by skilfully contrived ovens (wherein the heat plays every way about the bread, without yet suffering any of the smoke or steams of the fire to come at it, and wherein what degree of heat you please may be continued from first to last) better bread may be baked, than in our common ovens, where the bread rests upon the hearth, and the heat is continually decaying. Not to mention this, I say, physiology can enable us to confer a very grateful taste on very many of the things we eat, barely by a skilful and moderate untying and exciting the formerly clogged spirits, and other sapid parts contained in them. It can teach us to make better bread than is commonly eaten. And by discovering to us a better art of cookery, than *Apicius* and his successors have left us, and by substituting innocently sapid things, instead of those unwholesome ones, their deliciousness endears to men; it can teach us to gratify men's palates, without offending their healths: and in preserving of fresh meats, fruit, &c. beyond their wonted seasons of duration, the naturalist's skill may perform much more than you will readily believe.

Of pre-
serving
bisket from
putrefac-
tion.

AND yet to incline you not to be too diffident in this particular, let me inform you, that much hath been already performed, as to the preservation of aliments, even by those, that have not troubled themselves to make philosophical inquiries after the causes and remedies of putrefaction in bodies, but only have been taught by obvious and daily observations, that the air doth much contribute to the corruption of some bodies, and the exclusion of the air to the hindering it. I remember, the inquisitive and learned Mr. *Boreel* assured me some while since, that he had in his country, *Holland*, eaten bisket, that was yet good, after it had been carried from *Amsterdam* to the *East Indies*, and brought back thence again, (in which voyage, between two and three years are wont to be spent.) And to confirm my conjecture of the way of preserving this bread so long, he told me, that the curious merchant, whose it was, used no other art, than

than the stowing his bisket, well baked, in casks exactly calked; and besides carefully lined with tin, for the more perfect exclusion of the air: adding, that to the same end the biskets were so placed, as to leave as little room as possibly might be in the cask; which also was not opened, but in case of absolute necessity, and then presently and carefully closed again.

I MAY elsewhere tell you of an eminent naturalist, a friend of yours and mine, that hath a strange way of preserving fruits, whereby even goofberries have been kept for many months, without the addition of sugar, salt, or other tangible bodies: but all that I dare tell you, is, that he assures me, his secret consists in a new and artificial way of keeping them from the air.

Of preserv-
ing fruits.

BUT it seems more difficult, as well as more useful, to be able to preserve meat long without salt; for it is sufficiently known to navigators, how frequently, in long voyages, the scurvy, and other diseases, are contracted by the want of fresh meat, and the necessity of feeding constantly upon none but strongly powdered flesh, or salted fish: and therefore, he is much to be commended, that hath first devised the way to keep flesh sweet, without the help of those fretting salts men are wont to use to make it keep. This way is not unknown to some ingenious persons in *London*. One of the most noted of whom, upon my conjecturing, how it may be performed, confessed to me, that I had hit upon the way in general. But the most satisfactory account I could get of it was from an Englishman, that lately practised physick in the *East Indies*, who, finding I was no stranger to what I asked him about, told me freely, that he had seen both goat's-flesh, and hen's, so well preserved by this way, that though it were put up in the *East-Indies* a while before he came thence, yet he eat of it, and found it good and wholesome between the Islands of *Cape Verd* (as the seamen call them) and *England*; so that this meat continued sweet above six months, notwithstanding the heat and closeness of the ship, the excessive heat they met with, in their passage under the line, and consequently through the torrid zone; and that the way was only this, that the meat being well roasted, and cut in pieces, was carefully and conveniently ranged in a very close cask, into which, afterwards, there was poured as much butter melted, skimmed, and decanted from the grosser and ranker parts, as would fill up all the intervals left between the several pieces of flesh, and swim about them all, and thereby keep out the air from approaching them; and then the cask being exactly closed, was stowed up in a convenient place in the ship, and kept unopened till the meat was to be eaten. And it must not be omitted, that the relator, and others, that had the care of making provision for the voyage, were fain, instead of butter made of cow's-milk (which could not be had, where they took in their lading) to make use of that made of goat's, or ewe's-milk, which is not (as the Indians make it) so good, and to whose rankness he ascribed that, which he had observed in some of the meat buried in it, which he thought might have been preserved *longer and better tasted* (for *wholesome* and *incorrupt* he said it was) in our European butter; whose power to preserve meat buried in it, after due coction, hath been confirmed to me upon their own observation, by an experienced officer of the English fleet, that had the oversight of the provisions, and by others, that had opportunity to observe it.

Of preserv-
ing meats
wasted, for
long
voyages.

BUT how much the naturalists skill may advance the dietetical part of physick, by enabling men to make aliments much lasting than naturally they are, I must not here labour to convince you by other instances, that I may not anticipate what we have elsewhere to acquaint you with, from other men's experiments, and our own, about the conservation of bodies. Only I shall at present tell you in general, that I hope there will be ways found out to preserve even raw flesh it self (for of the keeping of roasted,

Of preserv-
ing raw
meats.

Salting
neats-
tongues
with salt-
petre.

Of preserv-
ing flesh in
spirit of
wine.

Of conserv-
ing by
sugar, and
making
sugar of
other con-
cretes be-
sides the
sugar.

And Joh.
de Laet,
describ. Indiar.,
l. 20. c. 3.

roasted, we have just now given you an instance) with things, that do not so much fret it, nor give it so corrosive a quality, when eaten, as our common salt doth. For not to mention what several curious persons have practised, of salting neats-tongues with salt-petre, which, though done only to make them look red, shews, that a body, not corrosive like common salt, may preserve flesh; I have, for trial sake, kept an entire puppy of a pretty bigness, untainted for many weeks, (and that in the midst of summer;) and that without flaying, drying (by fire, or otherwise) or so much as exenterating him, or cleansing him, or doing any thing towards the preserving of him, save the keeping him immersed in a well-stopt vessel, under spirit of wine, (from whose taste, I presume, meat may be easily freed by water;) and there seemed small cause to doubt, that the only thing, that hindered me from keeping him much longer, was the want of time to pursue the experiment, and take notice of its success. For I remember, I have the same way kept a soft substance, taken raw from an ox or cow, for many months (if I mistake not, eighteen or twenty) and found no putrefaction or ill scent in the immersed substance; which, for aught I know, might have been preserved divers years together the same way, or at least, by an easy improvement of this method, of which, I lately intimated, I intend you hereafter an account.

AND I shall further add on this occasion, that if we reflect upon sugar, which is (at least in these western regions) but an almost recent discovery, and consider how many bodies are with it, by confectioners and others, not only preserved, but rendered exceeding grateful to the taste; that single instance may suffice to make us think it probable, that expedients yet unthought of may, by an insight into nature, be found out, for the preservation of bodies: especially, if our ingenious friend Mr. W. would shew us, how out of divers other concretes, besides the sugar-cane, a substance not unlike sugar (though of different taste, according to the nature of the vegetable, that affords it) may, by a peculiar industry, be prepared. Which, that you may not think unfeasible, let me mention to you (for perhaps he hath not yet taken notice of it) what even Indians have done of this nature. And first, let me inform you of what we are told by *Linschoten* * concerning that drink, which in the *East-Indies* they call *sura*, and made of the liquor dropping from the blossoms, that they cut away from the Indian palm-tree, which bears the coco-nut. For this *sura*, he tells us, that amongst other things, they make sugar (which is called *jagra*) which is made by boiling that liquor, and setting it in the sun, where it congeals to sugar.

AND though I must not conceal from you, that our author adds, that it is not much esteemed by reason of its brown colour, and for that (to use his words) they have so great quantity and abundance of white sugar throughout all *India*; yet the latter reason, of the cheapness of *jagra*, seems to be the principal. For probably, if other sugars were scarce, the melioration of this would be attempted; and it is very likely, that if a skilful naturalist had the ordering of that sweet juice, of which the Indians make their *jagra*, he might very well make of it a sugar of no small use; and such a sugar would be very convenient in many cases, and to many persons, for its being different from the common sugar, though it should not be better. *Garcilassus* also (a much applauded writer concerning the *West-Indies*) treating of the fruits of a Peruvian tree, called by some *Molle*, and by others *Mulli*, *Conficiunt* (saith he) *ex eo potum confricando blandè inter manus in aqua calida, donec dulcor omnis defricetur*. Per-

* *Linschoten's Voyage*, chap. 56.—When they desire to have no cocus, or fruit thereof, (namely, of the palm-tree) they cut the blossoms of the cocus away, and bind a round pot, with a narrow mouth (by them called *calao*) fast to the tree, and then stop the same close round about with pot-earth, so that neither wind nor air can enter in, or come forth; and in that sort, the pot, in short space, is full of water, which they call *sura*, and is very pleasant drink, like sweet whey, and somewhat better.

colant hanc aquam, servantque dies tres quatuorve, donec subsideat; potus est limpidissimus, &c. *Aqua eadem cocta convertitur in optimum mel.* 'They make drink of that Mulli, rubbing it gently in their hands in hot water, until they have rubbed out all the sweetness; they strain that water, and keep it three or four days, until it settle, and then it becomes a very clear drink: the same water boiled turns into good honey.— Of this fruit boiled with water according to different manners is made wine, or good drink, or vinegar, or honey.' And of the same plant *Petrus de Cieca* hath this confirming passage: *Ex bujus fructu cum aqua decocto, pro cocturae modo fit aut vinum sive potio admodum bona, aut acetum, aut mel.* And that there is a great affinity betwixt such vegetable honies and fugar, especially if the juices be ordered with a design of turning them rather into fugar than honey, you may easily gather from the next and more memorable instance, which we are to mention, and which is afforded to us by the diligent describer of the Brazilian plants, who treating of the *Caraguata*, or *Erva Babosa* (or, as some would have it, *Herba innominata caule portulacæ*) hath these words to our present purpose: *Porro* (saith he) *radendo novacula petrosa stolones, emanat ex concavitate liquor quidam tantâ copiâ, ut ex una solummodo planta (mirabile dictu) interdum 50 aut plures arobæ affluant, è quo liquore fit vinum, acetum, mel, & saccharum: liquor quippe perdulcis coquendo redditur multo suavior & spissior, ita ut tandem in saccharum congelescat:* 'Then by cutting the shoot with a razor-blade made of a flint, there runs out of the cut a certain liquor in such a quantity, that (which is wonderful) out of one single plant, sometimes fifty or more *arobæ* run out: from which liquor there is made wine, vinegar, honey, and fugar. For the liquor, sweet of itself, is by being boiled made much sweeter and thicker, so that it at length kerns into honey.'

Apud eundem codem loco.

SINCE the writing of these last lines, being visited by an ancient virtuoso, governor to a considerable colony in the northern *America*, and inquiring of him, among other particularities touching his country, something in relation to the thoughts I had about the making of several kinds of fugar; he assured me, upon his own experience, that there is in some parts of *New England* a kind of tree, so like our walnut-trees, that it is there so called; whose juice, that weeps out of its incision, &c. if it be permitted slowly to exhale away the superfluous moisture, doth congeal into a sweet and saccharine substance: and the like was confirmed to me, upon his own knowledge, by the agent of the great and populous colony of the *Massachusetts*. And very lately demanding of a very eminent and skilful planter, why, living in a part of *America*, too cold to bear sugar-canes, he did not try to make fugar of that very sweet liquor, which the stalks of maiz, by many called Indian-wheat, afford, when their juice is expressed, he promised me he would make trial of it; adding, that he should do it very hopefully, because that though he had never been solicitous to bring this juice into a saccharine form, yet having several times, for trial sake, boiled it up to a syrup, and employed it to sweeten tarts, and other things, the guests could not perceive, that they were otherwise sweetened than with fugar. And he further added, that both he and others had, in *New-England*, made such a syrup with the juice of water-melons.

NOR, *Pyrophilus*, is it only by teaching men to improve the wholesomeness and tastes of the aliments, or to keep them long uncorrupted, that the naturalist may contribute to the preservation of man's health; for from the ingenious attempts of *Sanctorius*, in his *Medicina Statica*, we may be invited to hope, that there may be ways, as yet unthought of, to investigate the wholesomeness or insalubrity of aliments: as he, by the weight of bodies, after having fed on such and such meats, finds, that swine's flesh, melons, and some other things, that he names (in the third section) do much hinder insensible perspiration, and consequently are unwholesome; though, as I

That the naturalist may find out new ways to investigate the wholesomeness or insalubrity of aliments, proved by instances out of *Sanctorius's Medicina Statica*.

take

Sect. 3.
Aph. 96.

The difference in transpiration betwixt the times after ordinary diet, and after excess, tried by the weighing of man's body.

Difference in the weight of waters.

That chymical experiments may discover other qualities in waters.

take it, it were not amiss, that before such observations be framed into general and established aphorisms, they were carefully made in bodies of differing ages, sexes, and complexions, and with variety of circumstances. But then again, presuming these maxims to be judiciously framed, the same *Statica Medicina* makes it hopeful, that there may be unthought of methods found, whereby, by ways different from those formerly used by physicians, a man may be much assisted in the whole manner of ordering himself, so as to preserve health, and to foresee and prevent the approach of many distempers. And perhaps by such unthought of ways, divers paradoxes of concernment to man's health may be made out, as the diligent *Sanctorius* to that observation proposed in these words, *Semel aut bis in mense facto excessu in cibo & potu, die sequenti, licet sensibiliter non evacuet, minus solito perpendit annexus*, (in the following aphorism) addeth this important corollary: *Victus uniformis caret beneficio illorum, qui semel vel bis in mense excedunt: expultrix enim à copia irritata excitat tantum perspiratus, quantum sine statica nemo crederet*: 'If once in a month one eat or drink to excess, the day following, if he be weighed (though he hath suffered no sensible evacuation) yet then he will weigh lighter than is usual. A constant diet wants the help of those, that once or twice in a month do exceed: for the expulsive faculty being oppressed by too great repletion, stirs up so much of perspiration, as without the statics no one would believe.' And indeed experience hath informed us, that the promoting or suppressing of insensible transpiration, by which, in a day, the body may discharge it self of four or five pounds of excrementitious matter, hath a much greater power to advantage or prejudice health, than is wont to be taken notice of: so that we see, that the statics, which, though long known, were thought useless to physick, may afford several important directions in reference to the preservation of man's health; to which there are likewise other ways, whereby the naturalist may contribute. For he may also devise means, whereby to judge of the qualities of aliments, especially drinks, in their respective kinds, and likewise of the temperature of the air in this or that place assigned. We shall, in one of the following essays, describe to you a small slight instrument, by the help of which, one, that is acquainted with this or that particular sort of wine, may give a near guess, whether it be embased with water or not. And whereas in most hot countries, where water being the common drink, it is of great concernment to man's health to be able to make a good estimate of the salubrity of it; and whereas physicians are wont to think water, *ceteris paribus*, the better and purer the lighter it is; this instrument presently manifests, without any trouble of weighing in scales, what among any waters proposed is the heaviest, and which the lightest, and what difference there is of gravity betwixt them. And this disparity may sometimes be so great, that I remember some of our English navigators tell us, that upon bringing home a sort of water out of *Africa* into *England*, they found by the common way of ponderation, the African water in the same bulk to be about four ounces in the pound lighter than the English. And as the thickness or lightness of waters may be thus presently discerned by this hydrostatical way, so it is possible, by some chymical experiments, easily enough to discover some other qualities, wherein waters, that are thought to be of the same nature, differ from each other: as we find, that very many pump-waters will not bear soap, as rain-waters, and the generality of spring-waters will do. Some water will not dye scarlet, or some other particular colour, because they are secretly imbued with some kind of saline substance, that hath an operation it should not have upon the ingredients employed by the dyer. And I have sometimes discovered a latent sea-salt in water, where others suspected no such matter, by pouring into it a solution of good silver, made in aqua fortis. For as common salt, as well as the spirit of it, will precipitate

precipitate the metal out of such a solution, in the form of a white calx; so it seemed rational to conceive, that in case the water I suspected hath been imbued in its passage through the earth with a saline quality, though not conspicuous enough to be taken notice of by the taste, these saline corpuscles diffused through the water would, though faintly, act their parts upon the dissolved silver; and accordingly I found, that upon the mixtures of such waters, and the metalline solution, there would immediately be produced a kind of whiteness (from some parts of the metal precipitated by the salt :) to avoid which, I have often been fain to use, in places where I met with such waters, either rain-water, or that, which is freed from its common salt, by a slow distillation.

AND as for the temperature of the air, which is acknowledged to be of exceeding great consequence, both as to health, and as to the prolongation of life, and which is possibly yet of greater moment to both than most men imagine, the skilful naturalist's sagacity, if it were employed to that purpose, might probably find divers ways of discovering the qualities, and consequently the salubrity and unhealthfulness of the air in particular places. For the diligent *Sanctorius* (in the second section of this *Medicina Statica*) teacheth us, how to estimate the healthfulness and insalubrity of the air, by the weight of those men's bodies, that live in it. And besides this (nice) way, we see, that by the late invention of weather-glasses, it is easy to discern, which of two neighbouring houses, and which of two rooms in the same house, is the colder. And I remember I have sometimes bethought my self of a slight way (to be mentioned in one of the following essays) by the help of which it is not hard to determine, in which of two places proposed the air is, *ceteris paribus*, the dryer or the moister; and to give also some guess, both how much at the same time the air of one place exceeds that of the other, and how the temperature of the air changeth in the same place, at several times, either of those qualities. And that the differing operations of several airs, upon certain sorts of flesh hung in them, upon some fading colours, upon bodies subject to gather rust, or to be tarnished, and, in a word, upon divers other subjects, may be more considerable, than men seem yet to have taken notice of, I shall think it sufficient to have intimated in this place; being desirous to hasten to the following essay, (wherewith I am to conclude, what I have to offer to you concerning physick) that I may have the more time to employ on it.

That the naturalist may discover the qualities of particular airs.

ESSAY V.

Presenting some Particulars, wherein Natural Philosophy may be useful to the Therapeutical part of Physick.

AND now, *Pyrophilus*, the method, that we formerly prescribed to our selves (a little after the beginning of the first essay) requires, that we consider a while the Therapeutical part of physick, which is indeed that, whose improvement would be the most beneficial to mankind; and therefore I cannot here forbear to wish, that divers learned physicians were more concerned, than they seem to be, to advance the curative part of their profession; without which, three at least of the four others may prove indeed delightful and beneficial to the physician, but will be of very little

The introduction.

use to the patient, whose relief is yet the principal end of physick; whereunto the physiological, pathological, and semeiotical parts of that art ought to be referred. There was a while since a witty doctor, who being asked by an acquaintance of mine (himself an eminent physician, and who related this unto me) why he would not give such a patient more generous remedies, seeing he grew so much worse under the use of those common languid ones, to which he had been confined, that he could not at the last but die with them in his mouth? briskly answered, *Let him die if he will, so he die secundum artem*. I hope there are very few of this man's temper; but it were to be wished, that there were fewer learned men, that think a physician hath done enough, when he hath learnedly discoursed of the seat and nature of the disease, foretold the event of it, and methodically employed a company of safe, but languid remedies, which he had often before found almost as unable to cure the patient, as unlikely to kill him. For by such an unprofitable way of proceeding, to which some lazy or opinionated practisers of physick (I say some, for I mean not all) have, under pretence of its being safe, confined themselves, they have rendred their whole profession too obnoxious to the cavils of such empiricks, as he, that (as the Lord *Verulam* reports) was wont to say, your *European* physicians are indeed learned men, but they know not the particular cures of diseases; and (unreverently enough) to compare our physicians to bishops, who had the keys of binding and loosing, and nothing else. Which brings into my mind what Monsieur *De Balzac* relates (in his witty French discourse, of the court) of a physician of *Milan*, that he knew at *Padua*, who being content with a possession of his science, and, as he said, the enjoyment of the truth, did not only not particularly enquire into the cure of diseases, but boasted, that he had killed a man with the fairest method in the world: *E morto* (said he) *canonicamente, e con tutti gli ordini*. And such scoffs and stories are readily enough entertained by the major part of men, who send for physicians, not so much to know what ails them, as to be eased of it, and had not rather be methodically killed, than empirically cured. And it doth indeed a little lessen even my esteem of the great *Hippocrates's* skill, to find mentioned in his writings so many of his patients, of whom he concludes, that they died. And I had much rather, that the physician of any friend of mine should keep his patient by powerful medicines from dying, than tell me punctually when he shall die, or shew me in the opened carcass, why it may be supposed he lived no longer. But, *Pyrophilus*, my concern for mankind, and for the reputation of many excellent physicians, whose profession suffers much by the want of either industry or charity, in such as we have been speaking of, hath diverted me longer than I thought from telling you, that I suppose it will be not very difficult to persuade you, that this so useful therapeutical part of physick is also capable of being much improved by a knowing naturalist, especially if he be an intelligent and expert chymist, as in this essay we will suppose him.

CHAP. I.

That the naturalist may invent medicines chymically prepared, more pleasant than the ordinary Galenical ones.

SOME Paracelsian would, perhaps, set forth, how much more easy to be taken chymically prepared medicines are wont to be, than those loathsome and clogging Galenical potions, bolus's, &c. which are not only odious to the takers, but (which is much worse) are to many so offensive, that either the patients cannot get them down, or the incensed stomach returns them by vomit, before they have staid long enough in the body to do any more than discompose it. But I shall not much insist on this, because I think wholesomeness to be much more considerable in a remedy than pleasantness; though, I confess, I could wish, that physicians were more careful

to keep patients from being almost as much troubled by physick, as by the disease; and to cure, according to the old prescription, not only *cito* and *tuto*, but *jucunde* too: especially considering, that, as we were saying, the loathsomeness of some medicines maketh the stomach reject them, before they can have performed their operations. And it is, I presume, on this account as much as any other, that at Oxford learned and practical physicians, of your acquaintance, make very frequent use (on patients not feverish) of the resin of jalap, barely drawn with spirit of wine; since, as we have tried, six, eight, or ten, or more grains, of this almost insipid resin, being cleanly prepared, according to art, and with a little gum tragacanth, and half its weight of powdered cinnamon, or some such thing made up, may be taken in the morning in form of pills, instead of a potion; and is wont to evacuate plentifully enough, and yet gripe the patient much less than common purges. But, as I said, I shall not insist on this. I might better commend the usefulness of chymistry to the therapeutical part of physick, from hence, that it is probable, that even emptying medicines may, by the spagyrist's art, be so prepared, as not only to be less offensive than common purges or vomits in the taking, but to be less painful in the working: as I have often observed, both in myself and others, that upon the taking of the clear, and not loathsome mineral waters of *Barnet*, though the medicine wrought with me ten or twelve times in a morning, yet it did neither pain me, or make me sick, or disorder me for the remaining part of the day, any thing near so much, as a common pill or potion, that had wrought but once or twice, would have done. And I shall elsewhere (God permitting) teach you a preparation of silver, whereof about three or four grains being made up (with any proper conserve) into a little pill, is wont to make a copious evacuation of serum especially (in bodies, that abound with it) without making the patient almost at all sick, or griping him; insomuch that I know some persons, both physicians and others, with whom though this medicine work frequently in a day, and though (which is stranger) once taking of it will with some persons work so for two or three, or more days successively, yet they scruple not to go abroad and follow their business. And some, that take it, tell me, that when it works not with them, as for the most part, when it hath freed the body from superfluous serum, it will cease, and in some bodies will scarce purge at all, it neither puts them to pain, nor makes them sick.

AND now I am speaking of the painless ways of relieving the sick, I shall add, that there is another way, whereby it is to be hoped, many patients may be rescued from a great deal of pain; and that is, by finding out medicaments, that may in several distempers, that are thought to belong peculiarly to the surgeon's hand, excuse the need of burning, cutting, trepanning, and other as well painful as terrible manual operations of chirurgery. *Helmont* tells us, that he knew a country-fellow, who cured all fresh wounds by a drink, made (as I remember) of burnt *Tilia*. I have informed you in another essay, of the cure I observed to be made of the exulcerated tumours of one sick of the king's-evil, by the use of beer, altered by a little plant, that did not at all disturb the taker. If we may believe *Helmont* and *Paracelsus*, *Præcipitatus Diaphoreticus*, taken at the mouth, doth cure, to use his own words, *Carcinoma, lupum, & quodlibet Æsthiomenum cacoëthes ulcus, sive externum sive internum*. And if there be any truth in what hath been affirmed to me by several eye-witnesses, as well physicians as others, concerning the *weapon-salve*, and *powder of sympathy*, we may well conclude, that nature may perform divers cures, for which the help of chirurgery is wont to be implored, with much less pain to the patient, than the surgeon is wont to put him to. I know a very ingenious man, that is

An instance in resin of jalap, mineral waters and the Author's Pil. Lunares.

That the naturalist may find out inward medicines able to do chirurgical cures, proved by divers instances.

Helmont de febribus c. 14. See also the same author in Tract. quem vocat arcanz Paracelsi. Et lib. de Febr. c. 141

famous as well for his writings as for a remedy, wherewith he undertaketh to cure constantly the exulcerated cancers of women's breasts, without any considerable pain: but having not yet had opportunity to make trial of that which I have lying by me, I shall only tell you he assures me, that this medicine is indolent, and mortifies the ulcerous parts as far as they are corrupted, without disordering the party troubled with them; which I the less doubt because, that (to add thus much on this occasion) partly by the colour, &c. of this powder, and partly by his own confession to me, it seems to be a dulcification of arsenick, first fixt with nitre, and then carefully freed from its corrosivenes, by very frequent distillations of fresh spirit of wine. I shall ere long have occasion to teach you a drink, whereby exulcerated (but not cancerous) breasts have been very happily cured. The learned *Bartholinus*, in his late *Observations*, mentions the cure of some hurts in the head, done without trepanning, in cases, where that formidable and tedious operation is wont to be thought necessary. As for the terrible way of stopping the violent bleeding in great wounds, by searing the orifices of the vessels with hot irons, it would be little needed, if we knew such remedies, as that, which the inquisitive *Petrus de Osma*, in his *Curious Letter to Monardes from Peru*, mentions in this passage, which I find among his other observations: Anno (saith he) 1558, in urbe D. Jacobi, quæ est in provincia Chyle, quidam Indi captivi suras sibi amputârunt, & eas assas præ fame ederunt, & (quod mirabile dictu) cujusdam plantæ folia vulneribus imponentes, illico sanguinem sistebant: 'In the city of St. James, that is in the province of Chyle, certain captive Indians cut off the calves of their legs, and for hunger eat them, and (which is strange) applying the leaves of a certain plant to their wounds, immediately they stanch the blood.' I knew a rich man, extremely corpulent, who having long had a strange kind of fistula in his breast, and having travelled from one country to another, to consult with the ablest chirurgeons, was at length brought to that pass, that at a consultation they resolved, by opening his breast, to try, if they could track the winding fistula, and save his life: and as the instruments, for this said operation, lay upon the table, another famous chirurgeon casually coming into the house, told the patient, that he had an art of curing fistulas without cutting them open, and without any considerable pain or trouble: whereupon the rich man offering him what he pleased for the cure, the chirurgeon quickly performed his promise, as the patient himself, who shewed me his breast, confessed to me, and that by the use of an almost indolent remedy, which he purchased of the chirurgeon, and which by his favour came to my hands: and that even very ill-conditioned fistulas may be cured without chirurgical operations, by medicines taken at the mouth, I shall ere long have occasion to shew you by a notable example.

Apud monard. de simplic. medic. pag. 84.

Sir-Walter Raleigh's cordial.

In the mean time I shall add, that a man, whom I suppose you have often seen, having a while since received such a kick of a horse, as made the doctor and chirurgeon, that tended him, to conclude the part gangrenated, and the patient's condition, by the accession of a violent fever, so desperate, that they desired to meddle with him no longer; a large dose of Sir *Walter Raleigh's* cordial, sent him by an excellent lady you are nearly related to, not only freed him from his fever, and the delirium that attended it, but, to the wonder of all that observed it, restored the limb, that was concluded gangrenated, to its former soundness.

AND to bring credit to all these relations, I shall crown them with that memorable passage of *Gulielmus Piso*, of as great things, that he saw done by the illiterate Indians themselves: *Memini* (says he) *in castris membra militum globulis sclopetorum ista, & jamjam ab Europæis chirurgis, tam Lusitanis quàm Batavis, amputanda, barbaros recentibus*

recentibus gummi succis & balsamis à ferro & igne liberâsse, & feliciter restituisse. Oculatus itidem testis sum in nosocomiis relicta ulcera & gangrenas ab illis, vel solo succo tabaci, curata: 'I remember, that the limbs of soldiers wounded with gun-shot, to have been cut off by the advice of our European surgeons, both Dutch and Portuguese, those barbarous people by recent juices, gums and balsams to have freed them from knife and cauteries, and happily cured them. I also am an eye-witness, that with the juice of tobacco alone, they have cured wounds given over by our surgeons.'

What great use the Indians make of the juice of tobacco.

BUT, *Pyrophilus*, that the making of divers helps to recovery, less distasteful, or less painful to the patients, is not the only, nor perhaps the greatest service that chymistry may do him that attempts the cure of diseases, I shall now endeavour to manifest in some particulars.

CHAP. II.

AND first, the skilful naturalist, especially if a good chymist, may much assist the physician to discover the qualities of medicines, whether *simple* or *compound*; that the experiments of the Spagyrist may much contribute to the examining those many things themselves prepare, you will, I presume, easily grant. That also divers mineral waters are of the nobler sort of medicines, is sufficiently confessed on all hands; and it is known too, that the industry of chymists hath produced some good directions towards the discovery of the minerals predominant in divers medicinal springs: but I am much mistaken, if they have not left much for others to do, which may be easily done. And I scarce doubt, but that by the various ways, that might be proposed, of trying what such waters hold, and what saline or other qualities are predominant in them, not only the nature of those medicinal waters, that are already used, might be more thoroughly understood; but undetected properties might in many others, that are now not taken notice of, be discovered; of some of which ways of examining mineral waters, I may elsewhere give you an intimation. And I have made several trials, that have, I confess, much inclined me to think, that the fault is rather in us, than either in nature or chymistry, that men do not, by the help of chymical experiments, discover more of the nature of divers medicaments, than hitherto they seem to have so much as aimed at. For though the abstruse endowments of specifics will not, I fear, be learned in haste, otherwise than by particular trials and observations; yet many simples have other qualities, which seem chiefly to reside, though not in an elementary salt or sulphur, yet in a part of the matter that seems of kin to a salt or sulphur: such as sourness, saltiness, a caustick or a healing faculty, abstersiveness, and the like, upon whose account such remedies seem chiefly to work in a multitude of cases. And towards the investigation of such qualities, a chymist may oftentimes do much, without making all his trials in human bodies. But though, to illustrate this matter, I have sometimes made several experiments, yet not having now my notes and observations at hand, I shall only mention a few things as they offer themselves to my memory, reserving the more distinct handling of this subject to another opportunity; and the rather, because that till such phænomena have been more diligently observed, and reduced to their distinct sorts, I would have them looked upon but as hints to farther inquiries, not as sufficient authority to ground general rules on.

That the search of nature by chymistry in particular discovers the qualities of medicines.

THERE are some plants, whose juices, especially when the superfluous moisture is exhaled or abstracted, will, (some by the assistance of a gentle heat and filtration, and some, even of themselves, in time which I remember, hath in some succulent plants amounted but to a very few hours) coagulate in part into a kind of salt,

which

Of the nitro-tartareous salt in some vegetables.

which, if you please, you may call essential: and by this nitro-tartareous salt (as it seems to be) those vegetables, whose juice affords it (such as are, if I mistake not their names, parietaria, borrag, bugloss, &c.) may be discriminated from those many others, from whence it is not (at least by the same way) to be obtained. And possibly also these salts may, to a heedful surveyor of them, appear to differ enough from each other in shape, taste, or other obvious qualities, to deserve to be sorted into differing kinds.

If likewise we compare the essential salts and spirits of these plants, with those of scurvy-grass, brook-lime, and other vegetables, that are counted antiscorbutical, and abound in volatile and saline parts; and if we also examine other plants, by divers chymical operations, and observe not only their disposedness or indisposition to yield spirits or oils by fermentation, or without it; but those other particulars, wherein they will appear to agree with, or differ from each other: there is little doubt but such trials will make them discover, to a considering naturalist, much of their natures and properties, and especially of such as depend chiefly upon the plenty or paucity of the saline, unctuous, sour, spirituous, lazy, tenacious or volatile parts.

Difference in operation between acid and alkalizate salts.

It may be also observed, that the infusion or decoction of some plants, as of brazil, fenna, &c. will be heightened into a reddish colour, by putting alkalizate salts, as of tartar, or of pot-ashes, in the water that extracts their tinctures: whereas acid spirits, at least some of them, will much impair, if not destroy their colour; as a little aqua fortis will immediately turn a red tincture of brazil, made in fair water, into a pale yellow: whereas, on the other side, I have observed, that a small quantity of a strong solution of pot-ashes, dropt into an infusion of red-rose leaves, hath presently turned it into a muddy colour, that seemed to partake of green and blue, but was dark and dirty; whereas a little aqua fortis, or good spirit of salt poured into the same simple solution, did immediately turn it into a fine red, and so it would do the muddy mixture lately mentioned, if it were put to it in a far greater quantity. I observed also, that with a very strong (though clear and well filtrated) lixivium of pot-ashes, I could precipitate some part of the infusion or decoction of red-roses; which grosser parts, when the mixture was filtrated through cap-paper, remained like a dirty coloured (though somewhat greenish) mud in the filtre; the fluid and finer part of the mixture passing through in the form of a liquor, high coloured, almost like muscadine.

Of ink made by the decoction of divers astringent plants, with a little vitriol.

AND on this occasion, I remember, that as galls, a very stiptick vegetable excrement, will yield a decoction, with which, and copperas, the common ink is made; so divers other plants, of notably astringent parts, may be employed to the like use: for, by casting vitriol into a decoction either of oaken bark, or red-roses, or even a bare infusion of either log-wood, or sumach, to name now no other plants of the like nature, I have presently made a mixture, that might make a shift to serve for writing-ink; but whether all stiptick plants, or they only, will with vitriol make an ink, I refer to farther inquiry. And as a solution of vitriol, and the decoction of the above-mentioned plants, do precipitate each other to make ink; so I remember I have tried, that by dissolving the crystals of pure silver (made the common way with aqua fortis, or spirit of nitre) in a good quantity of fair water, that the liquor having no colour of its own, the colours it produceth in other bodies may be the better observed, I found, that I could with this liquor precipitate out of the infusions alone of several vegetables substances differently coloured, according to their respective dispositions. And so I have found, with less cost, that *saccharum Saturni*, which seems to be a kind of vitriol of lead, whilst it lies dissolved in the same spirit

Of some metalline precipitations.

of

of vinegar, which extracted it from the metal, being put to the bare infusion of log-wood, *lignum nephriticum*, red roses (to name those I now remember I made trial of) they will precipitate each other.

I MIGHT farther add, that I have tried, that sulphureous salts, such as oil of tartar, made *per deliquium*, being dropped into the expressed juices of divers vegetables, will in a moment turn them into a lovely green, though the vegetables were of colours differing from that, and from one another, (as I remember one of those vegetables, in which I expected, and found that change, was of a fine carnation.) And I could tell you, that though it be disputed, whether quick-lime have any salt dissoluble in water, and of what sort it is, the examen of that question may be much furthered, by trying, as I have done, that the water of quick-lime, well made, will precipitate a solution of sublimate made in fair water, and will presently turn syrup of violets (which is blue) if well mixed with it, into a fair green. Experiments, I say, of this nature I might easily annex; but having already set down divers of them in what I have written concerning colours, I shall refer you thither: and now only add this observation, that the investigation of divers medical qualities, even of animal substances, may be as much assisted by the naturalist, especially a chymist; as we elsewhere have by the distillation of the *calculus humanus* shewn, how much it differs from the stones, that are found in the earth. And if you take those hard concretions, found at certain times in the heads of craw-fishes, that are wont to be called *lapides cancerorum*, and commit some of them to distillation, and infuse some in vinegar, and others in old Rhenish-wine, or strong white-wine, you will probably discover something of peculiar in the nature of this concrete, of which I may possibly elsewhere make farther mention to you. And not only so, but in some animal substances, you may, by fit experiments, discover notable changes to be made, and their qualities to be much heightened, when the eye scarce perceiveth any change at all, as I have purposely observed, in keeping urine in close glasses, and a moderate heat for many weeks: for at the end of that time, the virtues, that depend upon its volatile salt, will be so heightened, that whereas upon putting spirit of salt to fresh urine, the two liquors readily and quietly mixed, dropping the same spirit upon digested urine, there would presently ensue a hissing and ebullition, and the volatile and acid salts would, after a while, concoagulate into a third substance, somewhat of the nature of sal-armoniack. And whereas the syrup of violets, formerly mentioned, being dissolved in a little fresh urine, seemed to be but diluted thereby, a few drops of the fermented urine tempered with it did presently turn into a deep green: and the same digested urine being dropped upon a solution of sublimate made in fair water, presently turned it white, by precipitating the dissolved mercury. With what (various) success we have likewise made upon some other parts of a human body, as well consistent as fluid, some trials, analogous to what we have recited of urine, I may elsewhere, perchance, take notice to you: but of such kind of observations I must give you but this hint at present.

CHAP. III.

SECONDLY: by these and other ways of investigating the medical qualities of bodies, the naturalist may be enabled to add much to the *materia medica*; and that two several ways.

FOR he may, by his several ways of trial, and by his chymical preparations discover, that divers bodies, especially of a mineral nature, that are as yet not at all employed by physicians, at least internally, may be brought into use by them; and that others, that are naturally so dangerous, as to be used but in very few, and for the

That sulphureous salts turn the expressed juices of vegetables into a green colour.

Of the distillation of the calculus humanus, and of the concretions, that are called lapides cancerorum.

The changes in animal substances made by fermentation only, particularly in urine.

Of the mixture of spirit of salt with digested urine.

That the search of nature adds much to the materia medica,

By employing bodies hitherto not employed.

Of remedies
newly pre-
pared out of
zink.

The cure of
the dropfy
by the pill
lunaris.

Of the use
of medicinal
earths.

Epitome
scientiæ
naturalis,
l. 2. c. 1.

Instances
of gold and
divers no-
ble men-
struums
drawn out
of them.

the most part extreme cases, may with safety be more freely employed. Some modern chymists (as particularly *Glauberus*) have of late prepared remedies not unusual out of zink or spelter. And I have already mentioned unto you an excellent medical use of silver, of which, prepared (as is there intimated) I have now this to add, that since I began to write of it to you, I met with a considerable person, who assures me, that she herself was by the use of it in a short time, cured of the dropfy, though, by reason of her having a body very corpulent, and full of humours, she have been thought more than ordinarily in danger of that stubborn disease. I have sometimes wondered, that there hath been so little care taken by physicians, and even by chymists, to investigate the qualities of mineral earths, and those other resembling bodies, that are, or may be plentifully enough digged up in most countries, though not the self-same in all; for however men are pleased to pass them slightly over, as if they were but elementary earth, a little stained, or otherwise lightly altered, I have seen great variety of them, that have been digged sometimes within the compass of a little spot of ground: and the differences of divers of them, both as to colour, taste, consistence, and other qualities, have been too great, not to make me suspect they were of very differing natures. And the true *bolus Armenus*, and the *terra Lemnia*, which is now brought us from the island, that gives it that name, (marked with a seal, which makes many call it *Terra sigillata*, though that name be for the same reason applied to the *terra Silesiaca*, and other medical earths) have been so esteemed, both by antient and modern physicians, as well against malignant diseases, and the plague itself, as against divers other distempers, that it is the more strange, that (since the greatest part of those two earths, that are now brought into our countries, have not, as the more skilful complain, the true marks of the genuine earths, whose name they bear) physicians have not been more careful to try, whether their own countries could not furnish them with the like, or as good, especially in regard some of the few attempts of that nature, that have of late times been made, may give them as much encouragement. For, not to believe the boasts of the Silesian *Johannes Montanus* (who passeth for the inventor of the *Terra sigillata Silesiaca Strigoniensis*) in the writing he published of the virtues of it, that it is gold prepared and transmuted, by provident nature, into an admirable medicine; I find that learned physicians prefer it before the Lemnian earth, that is now brought from *Turkey*. And the experienced *Sennertus* gives it this commendation, *Experimentis* (saith he) *multis jam probatum est, ejus insignes esse vires contra pestem, febres malignas, venenatorum animalium morsus, diarrhoeam, dysenteriam*: 'It is approved by many experiments, that its virtues are excellent against the plague, malignant fevers, the bitings of venomous creatures, the diarrhoea, and other fluxes.' What he adds, that the chymists name it *axungia solis*, brings into my mind (what I shall hereafter have occasion to mention more particularly to you) that I had once brought me a certain earth, by a gentleman, that digged it up in this, or some neighbouring country, which, though it seemed but a mineral earth, did really afford, to a very expert trier of metals of my acquaintance, a not despicable proportion of gold. They have also found in *Hungary* an earth, which they call *Bolus Tockaviensis*, which is affirmed by *Crato* (in *Sennertus*) to melt in the mouth like butter, and to have all the other proofs of the true *Bolus Armenus*, and therefore is, by that judicious physician, preferred before the modern bole-armony, even that, which was brought out of *Turkey* to the emperor himself. And he relates, not only its having succeeded very well against catarrhs, but his having experimentally found it of great efficacy in the plague, that reigned in his time at *Vienna*. To which I shall add, that a very learned and successful English doctor now dead did some years since, during a great plague, that then

then raged in the city, where he lived, find a vein of red earth, not very far from that town, and prescribed it with very good success in pestilential fevers, as I was informed by an ingenious friend of his, that used to administer it, and shewed me the place where he digged it.

I REMEMBER also, the experienced chymist *Johannes Agricola*, in his notes upon what *Poppius* delivers of *Terra sigillata*, after having much commended the *Terra Silesiaca* in divers diseases, and equalled it to the best of *Turkey*, where he had travelled relates one strange thing of it, with many circumstances, and in a way, as if he spoke upon his own trial; namely, that the spirit of *Terra sigillata*, by which I think he means the *Strigoniensis*, doth, though slowly, dissolve gold as well as an *aqua regis*, and that into a red solution; whence in two or three days the gold will fall of it self into a very fine and subtile powder. And the same author tells us, that he hath seen another earth digged at *Rheinstran*, not far from *Westerwaldt*, which was more inclinable to white than to yellow; which is preferable to the Silesian, and gives more salt than it, and dissolves silver better than other menstruums; since, as he saith, the silver may thereby be easily made potable, and be prepared into a very useful medicine for the diseases of the head. And for my part, I do not much wonder at the efficacy of these earths, when I consider, that divers of them are probably imbued, as well as dyed, with mineral fumes, or tinged with mineral juices, wherein metal or minerals may lie, as the chymists speak, in *solutis principiis*; in which form, having neither endured the fire, many of their usefulest parts are more loose and volatile, and divers of their virtues less locked up, and more disposed to be communicative of themselves, than they are wont to be in a more fixed or coagulated state, or when they have lost many of their finer parts by the violence of the fire.

BESIDES, there are several mineral bodies, which, though perhaps they may not be of themselves fit for the physician's use, may, by addition of some other convenient body, or by sequestration of the more noxious parts, or by some such other chymical preparation, as may alter the texture of such minerals, be rendered fit to increase the *Materia Medica*. As I have known, that by a preparation of arsenick, with salt-petre, whereby some of the more volatile and noxious parts are driven away, and the remaining body somewhat fixed and corrected by the alkali of the nitre, it hath, by a farther dulcification with spirit of wine, or vinegar, been prepared into a kind of *balsamum fuliginis*, which wonderfully cured a physician of my acquaintance, as himself confessed to me, of dangerous venereal ulcers (divers of which penetrated even to the *meatus urinarius*) which had reduced him to great extremity.

AND though bismutum have not, that I know, till very lately, been used, unless outwardly, and especially for a cosmetick (hereafter to be taught you,) yet the industrious chymist, *Samuel Cloffeus*, by calcination, and addition of spirit of vinegar, and *cremor tartari*, makes two medicines of it, which he highly extols in the droply; and (to reserve for another place, what I have tried upon tin-glass) a very expert chymist of my acquaintance doth, by preparing it with common sublimate (carried up by which, I remember, it hath afforded a very prettily figured body) make it into a white powder, like *mercurius vite*, which he assures me he finds, in the dose of a few grains, to purge very gently, without being at all, as *mercurius vite* is wont to prove violently enough, emetick.

2. BUT the naturalist may add to the *Materia Medica*, not only by investigating the qualities of unheeded bodies, but also by gaining admittance for divers, that, though well enough known, are forbore to be used upon the account of their being of a poisonous nature: for by digestion with powerful menstruums, and some other skilful ways of preparation, the philosophical spagyrist may so correct divers noxious, nay

Of medicines out of arsenick.

And out of bismutum.

Apud Schroderum in pharmacop. 1. 3. c. 18.

Dr. I. C.

Of the correction of poisonous medicines,

Helmont
de phar-
mac. &
dispens.
modern.
num. 46.

poisonous concretes, unfit in their crude simplicity for the physicians use, at least in any considerable quantity, as to make them useful and effectual remedies. *Helmont*, who, though frequently extravagant in his theory of physick, doth often make no bad estimate of the power of remedies, after having told us, that he adored and admired the clemency and wisdom of God, for creating poisons, gives this account of his so doing: *Nam venena* (saith he) *noluit nobis esse venena aut nocua. Nec enim mortem fecit, nec medicamentum exterminii in terra: sed potius, ut parvo nostri studio mutarentur in grandia amoris sui pignora, in usuram mortalium, contra futurorum morborum sævitiam. In illis nempe latitat subsidium, quod benigniora & familiaria simplicia recusant alias. Ad majores & heroicos medentum usus venena tam horrida servantur:* ‘He made not venom to be our poison, for neither made he death nor any deleterious medicament upon the earth; but so, that by a slight industry and endeavour of our own they might be turned into great pledges of his love, for the use of men against the cruelty of diseases, which were in process of time to arise. For in those venoms is the help, that more benign and familiar simples cannot yield; and those more frightful poisons are yet preserved in nature for the more great and heroick uses of physicians.’ And though I would not forbid you, *Pyrophilus*, to think there is some hyperbole in the encomiums he here and elsewhere gives poisonous simples; yet when I consider, what great things are oftentimes performed by antimony, mercury, and opium, even in those not over-skilful ways of preparing them, that are divers of them vulgarly used by chymists, especially when the preparations are (which doth seldom happen) rightly and faithfully made; I can scarce think it very unlikely, that those active simples may, by a more skilful way of ordering and correcting them, be brought to afford us very noble remedies. And the same examples may in part prevent the main objection, that I can foresee in this case, which is, that whatever corrects poisons, must, with their virulency, destroy their activity; for the above-named simples, though so prepared as to be medicines safe enough, have yet activity enough left them to let them be very operative, their energy being, by preparation, not only in part moderated, but in part so over-ruled, as to work after a more innocent manner: As in *bezoardicum minerale*, skilfully prepared, (for it very seldom is so) the laxative and emetick virulency of the antimony is changed into a diaphoretick, resolving, and deopillative power; which probably made the experienced *Riverius* (though counted a Galenist) so particularly recommend this medicine to physicians, which, if I be not mistaken, may well be praised without being flattered. And *Helmont* supplies me with an easy experiment to our present purpose, by telling us, that *asarum*, which when crude, doth, as is well known, provoke vomits, by a slight preparation (presently to be mentioned) is so altered, that its virulency is changed, to use his expression, in *deoppilans, diureticum tardarum febrium remedium*; which I the rather take notice of, because I find, upon enquiry purposely made of some ingenious physicians of my acquaintance, that upon trial, they commend this preparation of *Helmont*’s, and confess, that by it the *asarum* loseth its emetick, and acquires a diuretical quality.

Helmont,
tract. supra
allegato,
num. 46.
47.

The prepa-
ration of
asarum
turns it
from being
emetick to
be notably
diuretical.

Helmont.
p. 466.

Helmont.
de Lithiasi,
l. 7. c. 32.

Now that all other animal and vegetable poisons may be corrected, without losing their force with their virulency, is the affirmation of *Helmont*, concerning *Paracelsus*’s and his *sal circulatum (majus)*. And as for vegetables, he elsewhere tells us, that the *Lapis cancerorum* resolved in *formam*, as he speaks, *pristinæ lactis, habet remedium contra inclementias multorum vegetabilium vi laxante infamium*: ‘That the *lapis cancerorum* resolved into the form of its first milk affords an antidote against the violence of many vegetables, that are infamous for their being over-laxative.’ And I remember, that I knew two physicians, the one of which affirmed to me, his having seen trial made (by the

the help of a noble menstruum) of what *Helmont* here teacheth, and found it true; the other, a person severe, and apt enough to dissent from *Helmont*, assured me, that with the volatile salt of tartar, he had seen vegetable poisons, and particularly nappellus, so corrected by a light digestion with it, that it lost all its poisonous qualities: for proof of which, he freely offered me, to take himself as much of that fatal herb, as would kill three or four men, (but at that time, and in that place, I could not get any of the plant to make the experiment with.) And though I shall say nothing now concerning *Helmont's sal circulatum*, yet as to the volatilization of the salt of tartar, what I have seen scarce permits me to doubt, that it is possible. And if I could now clearly acquaint you with my reasons, you would perchance not wonder to find me inclinable to think, that some such methods (perhaps a menstruum) may be found to correct poisonous simples, without rendring them ineffectual. And though it must be some very powerful corrective, whether salt or liquor, that shall be able to correct any store of differing poisons; yet it is not irrational to think, that divers particular concretes may be prepared without any such abstruse or general corrective, some by one way of handling it, and some by another. And in such cases, skill in the natures of particular bodies to be managed, or lucky hits, may supply the place of a meliorating dissolvent; of which *Helmont* affords me a considerable instance, where he teacheth, in the place lately quoted, that the emetick property of asarum may be taken away, and the plant turned into a noble diuretick, only by boiling it a while in common water. And whereas a wary man would be apt to suspect, that this change is made but by the avolation of some subtil parts driven away by the heat of the boiling water, I find, that our author affirms, that though it be boiled with the like degree of fire, in wine, instead of water, it will not so lose its violence. I have known white hellebore, opium, and some other noxious bodies, so prepared, as to be given not only harmlesly, but successfully in such quantities, as were they not skilfully corrected, would make them pernicious. We daily see, that the violent emetick and cathartick properties of antimony, may singly, by calcination with salt-petre, be destroyed. And (which is though a known, yet a notable experiment among chymists) mercury sublimate may be deprived of its deadly corrosiveness, and prepared into a medicine inoffensive even to children, by bare re-sublimations with fresh mercury. And to give you one instance more of what the knowledge of the effects of chymical operations, and of the disposition of a particular body, may enable a man to do, in changinge the pernicious nature of it; I shall add, that the violently vomitive flowers of antimony, which our wonted, though sumptuous and specious cordials are so unable to tame, I can shew you (which perhaps you will think strange) so corrected, without the addition of any thing besides heat and skill, that in a treble dose, to that wherein they are wont to be furiously emetick, we have not found them to work otherwise than gently by sweat. But some more particulars applicable to our present purpose, you will meet with by and by.

CHAP. IV.

THIRDLY, and now, *Pyrophilus*, that I am speaking of the service, that the naturalist may do physick, I must not pretermitt, that he may assist the physician to make his cures less chargeable. For though to cure cheaply, be not properly, and in strictness, any part of the end of the art of physick, which considers men's health, and not their purse; yet it ought in charity, if not also in equity, to be the endeavour of the physician especially when he dealeth with patients, that are not rich. For not to say any thing of fees of physicians, which in some places are

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Instances in some of the secret menstruums.

That the preparation of asarum is only the boiling it in common water. Helm. in pharmacop. & dispens. modern. n. 46, 47.

That the boiling in wine alter not its violence.

That the emetick and cathartick properties of antimony are destroyed by calcination with salt-petre, and mercury sublimate be deprived of its corrosiveness by bare re-sublimations with fresh mercury.

A strange correction of the flowers of antimony.

That the naturalist may assist the physician to make his cures less chargeable.

not

not very moderate, it is certain, that the bills of apothecaries, especially in chronical diseases, do often prove so chargeable, than even when the remedies succeed, by that time a poor patient is recovered, he is undone; and pays, for the prolongation of his life, that, which should have been his livelihood. Whence it comes to pass, that the more necessitous sort of people are ever fain to languish unrelieved, for want of being able to purchase health at the apothecaries rate; or are deterred from applying themselves to the physician, till their diseases have taken too deep root to be easily, if at all, eradicated: and this oftentimes, not more through the fault of the apothecary, than of the doctor, who in his prescriptions might, for the most part, easily direct things, that would be much more cheap, without being much less efficacious.

Now there are several particulars, wherein it may be hoped, that the naturalist may assist the charitable physician to lessen the charge of his patients.

Inconveniences of
stuffing re-
cipes with
a multitude
of ingre-
dients.

AND first, he may persuade the physician to decline that more frequent than commendable custom, of stuffing each *recipe* with a multitude of ingredients. It is not, that I approve the practice of some chymists, who too freely censure the compounding of simples; for I know, at some times, a complicated distemper requires in its remedy more qualities, than are, perhaps, to be met with in any of the known simples, that the physician hath at command (though one and the same simple may sometimes answer divers indications; as a plant, that is hot and dry, may serve for a distemper that is cold and moist.) And I know too, that in some cases to that ingredient, that is as it were the basis of the medicine, other things must be added, either to correct its noxious qualities, or to allay its violence, or to serve for a vehicle to convey it to the part affected, or to make it easier to be taken by the patient, or to preserve it from corruption, or for some such like reason. But yet I think physicians may well be more sparing, as to the number of the things prescribed, than most of them use to be, both to save charges to their patients (upon which account it is, that I here mention it) and for other considerations. For the addition of needless ingredients adding to the bulk of the medicine, makes it but the more troublesome to be taken, and the more apt to clog the stomach. And oftentimes the efficacy of the more useful ingredients, as well as their quantity in each dose, is much abated, by their being yoked with those, that are less appropriated, or less operative. Besides, it seems a great impediment to the further discovery of the virtues of simples, to confound so many of them in compositions: for, in a mixture of a great number of ingredients, it is so hard to know, what is the operation of each, or any of them, that I fear there will scarce in a long time be any great progress made, in the discovery of the virtue of simple drugs, till they either be oftener employed singly, or be but few of them employed in one remedy. And besides all this, whereas when one of these mixtures is administered, the physician expects but such operations as are suitable to the quality, which he conceives will be predominant in the whole compound, several of the ingredients may have particular qualities that he dreams not of, which working upon a body, that the physician considers as subject only to the sickness he endeavours to cure, may therein excite divers latent seeds of other distempers, and make new and unexpected commotions in the body. On which occasion I remember, that whereas parsley is a very usual ingredient of aperitive and diuretick decoctions and apozems, a famous and learned oculist tells me, he hath very often observed, that when he hath unawares, or for trial-sake employed parsley, either inwardly, or even outwardly, to those, that were troubled with great distempers in their eyes, he found the medicines, wherein that herb was but one ingredient among many, to cause either great pain or inflammation in the eyes. In confirmation of which, I shall add, that a while after having a slight distemper in my eyes, I one day found it upon a sudden strangely

strangely increased, without being able to imagine, whence these new symptoms proceeded, till at length, recalling to mind all I had done that day, I remembered, that at dinner I had eaten sauce, wherein there was a pretty deal of parsley mixt with other things. And whereas in divers of these compositions some noxious ingredients are allowed, upon a supposition, that their ill qualities will be lost, by their being, as it were, tempered with the rest; though this may sometime happen, yet it would be considered, that in treacle (especially at one age of it) the opium doth not, considering the small proportion of it to the rest of the ingredients, lose much, if any of its power, by being mingled with sixty odd other drugs: which composition possibly owes much of its virtue to that little opium. And perhaps one reason, why those that accustom themselves to be ever and anon taking physick, though they often escape dangerous diseases, (by preventing the accumulation of humours, and taking their sicknesses at the beginning) are yet almost ever troubled with one distemper or other, may be, that by the multiplicity of medicines they take into their bodies, divers things are excited to disorder them, which otherwise would have lain quiet. I am not ignorant, that it may be alledged, that in compounded medicines, as treacle and mithridate, how many soever the ingredients be, they do so clog and temper one another's activity in the composition, that there results from them all one or more qualities fit for the physician's turn, and which is the thing he considers and makes use of. And I confess, that in some cases this allegation doth not want its weight: for I consider, that a decoction of galls, and a solution of copperas, though neither of them a-part be blackish, will, upon their mixture, turn to ink; and that when brimstone, salt-petre, and coals, are well mingled together in a due proportion, they make gun-powder, a mixture, that hath qualities much more active than any of the fever'd ingredients. But I fear, that when a multitude of simples are heaped together into one compound medicine, though there may result a new crasis, yet it is very hard for the physicians to know before-hand what that will be; and it may sometimes prove rather hurtful than good, or at least by the coalition, the virtues of the chief ingredients may be rather impaired than improved. As we see, that crude mercury, crude nitre, and crude salt, may be either of them safely enough taken into the body in a good quantity; whereas of sublimate, consisting of those three ingredients, a few grains may be rank poison. As for those famed compositions of mithridate, treacle, and the like, though I cannot well, for the mentioned reasons, commend the skill of those, that first devised them; and though I think, that when one or two simples may answer the same indications, they may for the same reasons be more safely employed; yet I would by no means discommend the use of those mixtures, because long experience hath manifested them to be good medicines in several cases. But it is one thing, to employ one of these compositions, when trial hath evinced it to be a lucky one, and another thing to think it fit to rely on a huddle of ingredients, before any trial hath manifested what kind of compound they will constitute. And, in a word, though I had not the respect I have for *Matthiolus*, and other famous doctors, that devised the compositions, whereinto ingredients are thrown by scores, if not by hundreds, yet however I should not reject an effectual remedy, because I thought, that it proved so rather by chance, than any skill in the contriver: and I think a wise man may use a remedy, that scarce any but a fool would have devised.

ANOTHER thing, upon whose account the naturalist (whom we here suppose an expert chymist) may assist a physician to lessen the expensiveness of his prescriptions, is by shewing, that in very many compositions, several of the ingredients, and oftentimes the most chargeable, whether they be proper or no for the disease, are unfit for the way of management prescribed, and consequently ought to be left out. I need not

not tell you, that since chymistry began to flourish amongst us, very many of the medicines prepared in apothecaries shops, and commonly the most chargeable, are distilled waters, spirits, and other liquors: and he, that shall survey the books and bills of physicians, shall find, that (very few perhaps excepted) the most usual prescription is to take such and such ingredients (for the most part numerous enough) and pouring on them either water or wine, if any liquor at all, to distil them *in balneo*, rarely in ashes or sand. But I confess, I have not without wonder, and something of indignation, seen in the prescriptions of physicians, otherwise eminently learned men, and even in the publick dispensatories, I know not how many things ordered to be distilled with others *in balneo*, which in that degree of heat will yield either nothing at all, as the fragments of precious stones, leaves of gold, prepared pearl, &c. or, if they do yield any thing, (for that hath not been yet, that I know of, evinced) do probably yield but a little nauseous phlegm, or at least some few loose parts, far less efficacious than those, that require a stronger heat to drive them up; such as sugar, raisins, and other sweet fruit, bread, hartshorn, flesh prepared by coction, &c. which, though wont to be thrown away with the *caput mortuum*, oftentimes there retain their pristine texture and nature, or at least are almost as much more considerable, than that which they yielded in distillation, as a boiled capon is, than the liquor, that sticks to the cover of the pot. And though as to some of these ingredients it may be thought, that they may yield even *in balneo* some of their useful parts, yet this can, with any probability, be supposed but of some such ingredients. And even as to them it is but supposed, that they may yield something in so mild a heat; and how that something will be qualified, is but presumed; at least, by the analogy of the experiments vulgarly made, there seems so small cause to expect, that these more fixed ingredients will add half so much to the virtue of the medicines, as they will to the cost; especially since, though it could be proved, or were probable, that fixed substances may communicate their virtues to wine or water, yet it would not follow, that those impregnated liquors, distilled *in balneo*, will carry those virtues with them over the helm. All which I have more largely proved in another discourse, where I shew both that the nobler parts of many ingredients, wont to be distilled *in balneo*, do commonly remain in the *caput mortuum*; and that it is very unsafe to conclude always the virtues of distilled liquors from those of the concretes, that afforded them.

But there is another way of putting unfit ingredients into medicines, by confounding those in one composition, which, though perhaps they might a-part be properly enough employed, do, when mixed, destroy or lock up the virtues of one another; and of this fault even famous chymists themselves are but too often guilty. I know not how many processes I have met with, wherein saline substances, of contrary natures, are prescribed to be mingled, as if because they were all of them saline, they must be fit to be associated; whereas it is evident to any man, that considers as well as employs the operations of chymistry, that there are scarce any bodies in the world, betwixt which there is a greater contrariety, than betwixt acid salts; and as well those that the chymists call volatile, as the spirits and salts of hartshorn, blood, flesh, and the like, as those others, which are made of incineration, as salt of tartar, and of all burnt vegetables. So that oftentimes it happens, that by an unskilful mixture two good ingredients are spoiled; as when vinegar, juice of lemons, juice of barberries, and the like, are prescribed to be distilled with other ingredients, whereof the salt of wormwood or some other plant makes one: for then the acid and alcalizate salts working upon one another, grow more fixed, and yield *in balneo* but a phlegm; and so spirit of urine, which is highly volatile, and spirit of salt, which is also a distilled liquor, being mingled together, will, by their mutual operation, constitute a new thing,

That acid and alcalizate salts being mixed, grow thereby more fixed, and yield in *balneo* but a phlegm.

thing, which in such a heat as that of a bath, will yield a phlegm, leaving behind the nobler and active parts con-coagulated into a far more fixed substance, much of the nature of sal-armoniack. And indeed where salts, especially active ones, are made ingredients of mixtures, unless they be skilfully and judiciously compounded, it often happens, that they spoil one another, and degenerate into a new thing, if they do not also spoil the whole composition, and of divers useful ingredients compose one bad medicine.

The same is observed of the mixture of the spirit of urine (by it self highly volatile, and spirit of salt.

CHAP. V.

ANOTHER way, by which the naturalist (skilled in chymistry) may help to lessen the chargeableness of cures, is by shewing, that as to divers costly ingredients, wont to be employed in physick, there hath not yet been sufficient proof given of their having any medical virtues at all, or that at least as they are wont to be exhibited, either crude, or but slightly prepared in juleps, electuaries, &c. there is not any sufficient evidence to persuade us, that their efficacy is as much greater than that of many cheap ingredients, as their price is. I am not altogether of their mind, that absolutely reject the internal use of leaf-gold, rubies, sapphires, emeralds, and other gems, as things, that are unconquerable by the heat of the stomach: for as there are rich patients, that may, without much inconvenience, go to the price of the dearest medicines; so I think the stomach acts not on medicines barely upon the account of its heat, but is endowed with a subtil dissolvent (whence soever it hath it) by which it may perform divers things, not to be done by so languid a heat. And I have, with liquors of differing sorts, easily drawn from vegetable substances, and perhaps unrectified, sometimes dissolved, and sometimes drawn tinctures from gems, and that in the cold. But though for these and other considerations, I do not yet acquiesce in their reasons, that laugh at the administration of crude gems, &c. as ridiculous; yet neither am I altogether of their adversaries mind. For though I deny not the glass of antimony, which looketh like a kind of gem or ruby, will easily enough impart to liquors an emetick quality; yet I know too, there is great odds betwixt rubies and other gems (which will endure violent fires, and remain undissolved in divers strongly corrosive liquors) and the glass of antimony, which is a body so far less compact and fixed, that spirit of vinegar it self will work upon it, and a strong fire will, in no long time, dissipate it into smoke. But that, which I chiefly consider on this occasion, is, that it is one thing to make it *probable*, that it is *possible*, gold, rubies, sapphires, &c. may be wrought upon by a human stomach; and another thing to shew both, that they *are wont* to be so, and that they *are* actually endowed with those particular and specifick virtues, that are ascribed to them: nay, and (over and above) that these virtues are such and so eminent, that they considerably surpass those of cheaper simples. And I think, that in prescriptions made for the poorer sort of patients, a physician may well substitute cheaper ingredients in the place of these precious ones, whose virtues are not half so unquestionable as their dearness.

That the naturalist discovers the mis-application, and use of gems, and divers other costly ingredients.

A difference between the fixedness of a gem, and of glass of antimony.

WHAT strange excellency there may be in the *aurum potable*, made by a true *adeptus*, or by a possessor of the liquor alkahest, I shall not now dispute, not knowing what powerful and radical dissolvents, the profound skill of such men (if any such there be) may furnish them with to open the body of gold. But as for the attempts and practices of the generality of chymical physicians to make gold potable, besides that their attempts to make their solutions volatile succeed so seldom, that even learned physicians, and chymists have pronounced the thing it self unfeasible; I confess, I should much doubt, whether such a potable gold would have the prodigious virtues its encomiasts ascribe to it, and expect from it. For I find not, that those I have yet

Concerning aurum potable.

met.

met with, deliver these strange things, upon particular experiments duly made, but partly upon the authority of chymical books, many of which were never written by those, whose names they bear. And others, I fear, commend *aurum potabile*, prepared after another guise manner, than that we are now speaking of, partly upon a presumption, that if it be made volatile, it must be strangely unlocked, and exalted to a mere spiritual nature; and partly upon rational conjectures (as they think them) drawn from the nobleness and preciousness of gold. But for my part, though I have long since bethought my self of a way, whereby I can, in a short time, and a moderate fire, make my menstruum bring over crude gold, in quantity sufficient to make the liquor look, at the first or second distillation, of a high golden colour; yet finding, that I could, by an easy art, quickly recover out of this volatile liquor, a corporal and malleable gold, I dare not brag, that my tincture (as an alchymist would call it) must needs do strange feats, because there is so noble a metal brought over in it. And if this or other preparations of *aurum potabile* prove good medicines, it would be farther inquired, whether the virtues may not in great part be rather attributed to the menstruum, than the gold, (that requiring a very subtle liquor to volatilize it) or to the association of the corpuscles of the gold, with the saline particles of the menstruum, into a new concrete, differing enough from gold, though never so well opened. And as for the nobleness and preciousness of this metal, that depends upon the estimation of men; whence in *America* the Indians, that abound with it, had not such a great value for it. And in divers countries, at this day, it is postponed to iron, or to copper, and hath rather a political (if I may so speak) than a natural virtue. Nor will it follow, that because it is the fixedest and preciousst of metals, that therefore it must be an admirable medicine: for we see, that diamonds, though they be the hardest of bodies, and very fixed ones, and in much greater esteem, *ceteris paribus*, than gold, are yet so far from being accounted highly medicinal, that they are commonly (though perhaps not so deservedly) reckoned among poisons. But I see I have digressed; that, which I chiefly aimed at, being to inculcate, that whether gold and gems, and the like precious ingredients, may be good medicines or no, it were a good work to substitute cheap ones for the poorer sort of patients; and that physicians are much to blame, who prize simples, as druggsters do, according as they are brought from remote countries, and are hard to come by; and cannot imagine, that what doth not cost much money in the shops, can do much good in the body; as if God had made provision only for the rich, or those people, that have commerce with *China* or the *Indies*: whereas indeed it may oftentimes happen, that what the chymists call their *caput mortuum*, and perhaps throw away as an useless *terra damnata*, may have as great virtues, as those nobler parts, as they call them, which they have extracted from it; and a despised simple, nay even an excrement or an insect, may in some cases prove nobler remedies, than those, that men call and think very noble bodies, not to say, than I know how many extracts and quintessences.

Examples
of great
medicines
drawn from
unpromis-
ing bodies.

Of the effi-
cacy of un-
promising
medicines.

I SHALL not trouble you with many instances to prove this doctrine, having more fully discoursed of it, in one part of another treatise. But yet some instances, I suppose, you will here expect, and therefore I shall present you with a few of those, that at present come into my mind.

WHEN the distillation of aqua fortis is finished, the *caput mortuum*, as deserving that name, is wont, by common distillers, to be thrown away; and I have seen whole heaps of it thrown by, as useless, by those, that make aqua fortis in quantity to sell it. And yet this despised substance doth, in common water it self, yield a salt, which being only depurated by frequent solutions and filtrations, is that famous *Panacea applicata*, or *arcantum duplicatum*, which that great virtuoso and knowing chymist, the Duke

Duke of *Holftein*, whose name it also beareth, thought worth purchasing at the rate of five hundred dollars, and of which the prince's experienced physician thus writes to the industrious *Schroder*: *Mille experimentis salis hujus efficaciam aula nostra comprobavit in melancholicis affectibus, febribus quibuscunque continuis & intermittentibus, calculo, scorbuto, &c. Quin & somnum conciliasse præsertim in melancholicis non semel notavimus. Dosis à scrup. 1. ad scrup. 2. Libras aliquot quotannis absumimus*: 'Our court hath tried the efficacy of this salt in a thousand experiments in the diseases of melancholy, in all fevers, continuous and intermittent, in the stone, scurvy, &c. Nay more, we have observed more than once, that it hath procured sleep, especially in persons of melancholy. The dose is from one to two scruples; we use divers pounds of it in a year.' And another very skilful physician, that frequented that excellent prince's court, confirmed to me the same medicine's diuretick and deoppilative virtue. (But upon my own experience I can say little of it, having casually lost a great quantity I caused to be prepared to make trial with, before I had opportunity to imploy it.)

BUT whereas in the *caput mortuum* of aqua fortis there remains pretty store of easily soluble salt, in the *caput mortuum* of vitriol, when not only all the oil is forced away by the fire, but all the fixed salt is exactly separated by water, there seems to remain nothing but a worthless *terra damnata*. And yet it is of this, that, as I shall teach you ere long, I make those colcotharine flowers, which are possibly a nobler medicine than either the oil, the spirit, or the salt of vitriol.

As for the bezoar-stone, which is so often prescribed by physicians, and so dearly paid for by patients, the experienced *Bontius*, a very competent witness in this case, (and whose account of the manner of its generation agrees the best, of any I have seen, with that I received from an intelligent person, that was imployed into *Persia* by the late king) hath in one place a passage concerning it; and elsewhere writes such things of the stone cut out of a man's bladder (though that, whilst crude, be despised as a thing vile and useless in physick) as may be justly applicable to our present purpose: *Cæterum* (saith he, speaking of the Bezoar-stone) *quantum ad hyperbolicas hujus lapidis virtutes & facultates portentosas non tantas in eo mille experiētiis edoctus inveni*: 'But for the exceeding and portentous virtues of the bezoar-stone I have found by a thousand trials, that they are not so very great.' And elsewhere speaking of those contemptible and excrementitious stones, that are found in human bladders, *Nil porro* (saith he) *de his lapidibus addo, ne videar eos elevare, & lithotomos monere, ut vel cum periculo plures mortales secent. Hoc certè compertum habeo, lapidem in vesica hominis repertum, urinam & sudores probè ciere, quod tempore ingentis illius pestis, quæ anno 1624, & 1625, Leydam patriam meam, & reliquas Hollandiæ civitates miserandum in modum vastabat, in penuria lapidis bezoartici nos exhibuisse memini, & sudorificum (ausim dicere) melius & excellentius invenisse, &c.* 'I speak no more of these stones, lest I should seem by my commendation of their virtues to provoke lithotomists to make dissections at any rate. This I have most certainly experienced, that the stone found in man's bladder doth well provoke urine and sweat. And particularly in the time of that plague, which in the years 1624 and 1625 miserably vexed ours, and all other the cities of *Holland*, for want of the bezoar-stone, I remember, I prescribed this, and found it (let me tell you) a more great and excellent sudorifick.'

Soor is generally looked upon as so vile a thing, that we are fain to hire men to carry it away; and yet, as I elsewhere shew, that it is a body of no ignoble nature, so I must here tell you, that it is no unuseful one in physick. And not to mention, that *Riverius* commends it crude to the quantity of a drachm in pleurifies; I have tried, with the spirit of it well drawn, some things, that make me look upon it as a considerable liquor. And I know by their own confessions, that some medicines,

The Duke of Holfstein's Panacæa duplicata is made of the vulgarly despised caput mortuum of aqua fortis.

Schroder. pharmacop. l. 3. c. 23

Flores Colcotharini are made of the caput mortuum of vitriol.

Bontius in c. 45. Garcia ab Orta. A comparison between the bezoar-stone and the stone cut out of man's bladder.

Idem, c. 46. Garcia ab Orta.

Medicines out of soot,

even of eminent physicians, that pass under other names, have the spirit of foot for their principal ingredient. I knew a not unlearned empirick, who was exceedingly cried up for the cures he did, especially in difficult distempers of the brain, by a certain remedy, which he called sometimes his *Aurum potabile* and sometimes his *Panacea*; and having obtained from this man, in exchange of a chymical secret of mine he was greedy of, the way of making this so celebrated medicine, I found, that the main thing in it was the spirit of foot, drawn after a somewhat unusual, but not excellent manner; in which spirit, flowers of sulphur were, by a certain way, brought to be dissolved, and swim in little drops, that looked of a golden colour.

The use of
horse-dung.

You will easily grant, *Pyrophilus*, that there are not any medicines to be taken into the body more cheap and contemptible, than the excrements of men and horses, and than insects; and yet that even these want not considerable medical virtues, we elsewhere shew. And (not to meddle with such nasty things, as the grosser sort of human excrements, though they, outwardly applied either in powder or otherwise, do sometimes perform strange things) the juice of horse-dung, especially of stone-horses, being strongly expressed (after the dung hath been a while steeped in ale, or some other convenient liquor, to facilitate the obtaining the juice, and to afford it a vehicle) doth oftentimes so powerfully relieve those, that are troubled with the stoppage of urine, with wind, stitches, and even with obstructions of the spleen and liver, that you, *Pyrophilus*, and I, know a great lady, who, though very neat, and very curious of her health, and wont to have the attendance of the skilfullest physicians, scruples not, upon occasion, to use, as I have known her do, in silver vessels, this homely remedy, and prefer it to divers rich cordials, and even to what some chymists are pleased to call *Essences* or *Elixirs*. And with the same remedy very many poor people were cured of the plague it self, when it lately swept away so many thousands in *Ireland* (and the doctors with the patients, as I was assured by a person who cured so many) as to invite men to secure themselves that assistance, by refusing the party the liberty to leave the town. But (to add that upon the by) this person, in exchange of a secret of mine, confessed to me, that the *arcanum*, which had cured such numbers, and to which the juice of horse-dung was a *succedaneum*, was only a good dose of the powder of fully ripe ivy-berries, which did usually, as also the horse-dung, work plentifully by sweat, and which I presently remembred to be one of those few things, that *Helmont* commends against the plague.

An arcanum of ivy-berries.

Medicines
out of man's
body.

THE medical virtues of man's urine, both inwardly given, and outwardly applied, would require rather a whole book, than a part of an essay, to enumerate and insist on: but referring you to what an industrious chymist hath already collected touching that subject, I shall now only add, that I knew an ancient gentlewoman, who being almost hopeless to recover of divers chronical distempers (and some too of these abstruse enough) was at length advised, instead of more costly physick, to make her morning-draughts of her own water; by the use of which she strangely recovered, and is, for aught I know, still well. And the same remedy is not disdained by a person of great quality and beauty, that you know; and that too after she had travelled as far as the *Spaw* for her health's sake. And I remember on this occasion, that passing once through one of the remoter parts of *England*, I was visited by an empirick, a well-wisher to chymistry, but a novice in it, who pressing me to communicate to him some easy and cheap preparation, that he might make use of among the country-people; I directed him to distil with a gentle heat a spirit out of urine, putrified for six or seven weeks on a dung-hill, or some analogous heat, but in well-closed glasses, or other glazed vessels; and having rectified this spirit once or twice, that it might be

be rich in volatile salt, to give ten, twenty, or thirty drops of it in a convenient liquor for the pleurisy, for most kind of coughs, and divers other distempers, as a *succedaneum* to the essence of harts-horn. And a while after, this empirick returned me great thanks for what I had taught him: and I found by him and others, that he had cured so many with it, especially of pleurisies (a disease frequent and dangerous enough in that country) that this slight and seemingly despicable remedy had already made him be cried up for a doctor, and was like to help him to a comfortable subsistence.

GREAT store of healthy men's blood is wont to be thrown away, as altogether useless, by chirurgeons and barbers, that let men blood (as is usual in the spring and fall) for prevention of diseases; and yet from a man's blood skilfully prepared, though without addition of any thing, save spirit of wine to keep it at first from putrifying, may be easily obtained a spirit and volatile salt, that have much the same virtues with those of the newly mentioned spirit of urine, but more noble (as far as I can guess) than either that, or even spirit of harts-horn; as having performed in consumptions, asthma's, and other obstinate cases, such things, as I, as well as others, could not but admire. But in this place, mentioning human blood only *in transitu*, I shall pretermitt what I have observed about the preparation of it; yet leaving you a liberty to call for my observations upon a medicine, which perhaps is nobler, than the most costly and elaborate chymical remedies, that are wont to be sold in shops, and which hath been almost alone excepted out of the censure made by a learned modern writer, of the medicines found out by chymistry:

I SHALL add but one instance more, of the efficacy, that may be found in the most obvious and abject creatures; and this instance is afforded me by those vile insects, commonly called in English, wood-lice, or sows, and in Latin *millepedes*; which I have often both recommended to others, and taken my self. What their virtue is against the stone, the world hath been informed by *Laurembergius*, who hath published a narrative, how by the use of them he was cured, even of the stone in the bladder; and he was invited to use them by credible information, that others had been cured of that disease, by the same remedy. And of late years in *England*, an empirick being much resorted to, for the relief he gave in that tormenting sickness, a physician, famous for his learned writings, wondring at what was done, was very curious (as himself afterwards told me) to find out the empirick's secret, and at length was so industrious as to discover, that it was a slight preparation of *millepedes*. But my having found them in my self very diuretical and aperitive is not that, which chiefly recommends them to me; for I knew, and lived in the same house with a pious gentlewoman, much better skilled in physick, than her sex promised, who having lost the use of one eye by a cataract, and being threatned by the oculists with the speedy loss of the other, especially in regard of her being very aged and corpulent, she nevertheless did, for some years, to my wonder, imploy her eye to read and work with, without finding, as she told me, any decay in it, or any increasing danger of a suffusion: and she assured me, that her medicine was to bruise first five millepedes, then ten, then fifteen, then twenty, &c. (daily increasing the number by five, till it had reached, if I mistake not, fifty or sixty) in white-wine (or small-ale) and to drink upon an empty stomach the strongly expressed liquor; and when I desired to know, how she came by this specifick, she answered me, that having made inquiries among all those, both oculists and others, that she thought might assist her against so sad a distemper, she was advised to the use of millepedes, by a woman, that not only much magnified their virtue in such cases as hers, but assured her (if I much misremember not) that she her self had been cured by them, of no less than an incipient suffusion in one or both of her eyes.

Medicines
out of
blood.

The great
effects of
millepedes
in the stone.

In suffusions
of the eyes.

And real
cataracts.

In sore
breasts and
fistulas.

[SINCE the writing of the former pages, relating what I newly told you to a very ingenious physician, he assures me, that being some years since in *Holland*, he there met with a woman, who was cured, as herself confessed to him, of a real cataract, by the juice of millepedes, beginning with that of three at a time, and so increasing to nine at once, and then gradually lessening the dose by one insect each day, till she were come back to three at a time; after which, she gradually increased the dose as before. And he adds, that this woman was advised to this medicine by an empirick, that was said to have performed divers cures with the same medicine.]

[WHAT strange things these same millepedes have done in the fore, and even ex-ulcerated, breasts of women (provided they be not cancerous) though they be given without preparation only to the number of three at first, and so on to nine at once (which number may perhaps be usefully increased) stamped with a little white-wine or beer, that the liquor strained out may be drank in a draught of beer, morning and evening; during which time, linnen cloaths dipped in white-wine, and applied warm, are to be kept upon the breast; I may elsewhere have a fitter opportunity to relate. I shall now only subjoin, as a further proof of the great virtue, that may be even in-vile and costless insects, and that without any elaborate or chymical preparation, this memorable story; that after all the trials I had made about these millepedes, I met with a young lady, who by divers strangely winding and obstinate fistulas, that had made themselves orifices in many places of her body, was not only lamed, but so consumed and weakened, that she was scarce able to turn her self in her bed; and this, notwithstanding the utmost endeavours of the eminentest chirurgions, both English and foreigners, that could be procured: but when both the hopes of her friends, and those, that endeavoured to cure her, were lost, she was in a short time not only freed from her fistulas, but recovered to a thriving condition of body, by the frequent use of an internal medicine, which, as both her parents, and the person, that taught it them, informed me, was only a drink (to be taken twice or thrice a day) made of a small proportion of a couple of herbs, (very common, and not much more likely to do wonders in this case, than wormwood and mint;) and of three hundred of these millepedes well beaten (when their heads are pulled off) in a mortar, and tunned up with the herbs, and suspended in four gallons of small ale, during its fermentation. The wonderful efficacy of this medicine in this and many other cases, which by occasion of this cure were related to me, being almost wholly ascribed to the millepedes, by the illustrious imparter of it, whose leave I have not yet, by naming him, to disclose, that this is the secret he makes use of.]

C H A P. VI.

That the
naturalist
discovers
how much
of the cost
and labour
in making
many chy-
mical reme-
dies may be
saved.

ANOTHER way there is, whereby the naturalist may assist the physician to make the therapeutical part of physick less chargeable; and that is by shewing those, that are wont to employ most chymical remedies, that much of the cost and labour in many cases might be spared. I am not altogether of their mind, that indiscriminately cry down chymical preparations as excessively dear: for of many of those that seem very dear, when bought by the pound or the ounce, a dose may be cheap enough. As if, for instance, an ounce of precipitate of gold, and mercury, cost ten times its weight of silver, under which rate I have bought it of honest men, that make it themselves, yet that ounce containing 480 grains, (of which three or four may be a dose) a taking of this dear powder may cost far less than a dose of many Galenical medicines, where the quantity, that is taken at once, makes up what is wanting in the costliness of the ingredients. But though this be the case of some chymical remedies, yet we must not deny, that many others are chargeable; and though

though perhaps not more so than many Galenical ones employed for the same purposes, yet if those be dearer than they need be, that grievance ought to be redressed in chymical medicines, how justly soever the same thing may be imputed to Galenical ones.

Now there are two particulars, wherein the chymists, and those physicians, that imitate them, are wont to be blameable in reference to this matter; the one their employing chymical preparations on all occasions, even where simples or slight compositions might serve the turn; and the other is, their making many of their preparations more laborious, and consequently more chargeable than needs.

As for the first of these: it is known there are divers chymists, and others, that practise physick, who so doat upon the productions of their furnaces, that they will scarce go about to cure a cut finger, with less than some spagyric oil of balsam; and in slight distempers have recourse to chymical, and perhaps to mineral remedies, which being, for the most part, such as vehemently alter the body, especially by heating and drying it, they do often more harm than good, when employed in cases, that need not such active medicines. And methinks those, that practise, as if nature presented us nothing worth the accepting, unless it be cooked and perfected by *Vulcan*, might consider, that *Paracelsus* himself oftentimes employeth simples for the cure even of formidable diseases. And though for particular reasons I be inclinable enough to think, that such searching and commanding remedies, as may be so much of kin to the universal medicine, as to cure great numbers of differing diseases, will be hardly obtained without the help of chymical preparations, and those perhaps of minerals: yet as to most particular diseases, especially when not yet arrived to a deplorable height, I am apt to think, that either simples, or cheap or unelaborate Galenical mixtures, may furnish us with specifics, that may perform much more than chymists are wont to think, and possibly be preferable to many of their costly magisteries, quintessences, and elixirs. *Helmont* himself, a person more knowing and experienced in his art, than almost any of the chymists, scruples not to make this ingenious confession: *Credo (saith he) simplicia in sua simplicitate esse sufficientia pro sanatione omnium morborum*: 'I believe simples in their own simplicity are sufficient for the curing of all diseases.' And elsewhere he truly affirms, that there may be sometimes greater virtue in a simple, such as nature affords it us, than in any thing that the fire can separate from it. And certainly the specific properties of divers, if not most simples, are confounded and lost by those preparations, wherein that texture, which is the foundation of those properties, is either destroyed by the fire, or changed by the taking away of some of the parts; or the adding of some other substance to it, with which compounded, it may constitute a new thing. The more judicious of the chymists themselves do several of them now acknowledge, that the bare reducing of pearls to fine powder, affords a medicine much richer in the virtues of the pearls, than the magistery, prepared by dissolving them in acid spirits, and precipitating them with oil of tartar, and afterwards scrupulously edulcorating them. And one may easily observe, that by making the magistery of harts-horn the same way, the virtues seem to be more locked up than they were in the crude horn; which may easily enough impart its virtue in the body, since fair water will reduce a good part of it into a jelly; whereas the magistery remains a fixed powder not easily dissoluble, even in acid menstruums; and, which thrown upon hot iron, will scarce send forth that stinking smoke, which argues the avolation of the saline and sulphureous parts. I never knew any of the vulgar chymists essences or elixirs half so powerful a remedy to stanch blood, as a slight mixture of two drachms of hyoscyamus, or henbane seed, and the like weight of white poppy-seeds, beaten up with an

A comparison of chymical remedies with Galenical ones in point of cheapness.

Of the use and commendation of simples, even by the most able chymists.

Helmont. Pharmac. & Dispensat. Nov. p. 458.

Powder of pearl more operative than magistery.

So crude hartshorn, than magistery.

An excellent simple medicine to stanch blood.

Another
like medi-
cine for
spitting
and vomit-
ing of blood.

an ounce of conserve of red-roses, into a stiff electuary; with which, given in the quantity of a nutmeg, or wall-nut, I have snatched some, as it were, out of the jaws of death; and with which an eminent physician, now dead, affirmed, that he, and the inventor of the remedy, had very frequently cured profuse bleedings at the nose; and in women, at other parts besides. Nor did I ever see, to give an instance in a resembling disease, such wonderful effects against spitting and vomiting of blood, of the most elaborate chymical preparations, as I have of a slight syrup, made only of a convenient quantity of fine sugar, and the strongly expressed juice of twelve handfuls of plantane leaves, and six ounces of fresh comfrey roots well beaten together: with which syrup, besides what I have tried myself, two eminent physicians performed in that disease unusual cures, though (for reasons elsewhere mentioned) I forbear to name them, otherwise than by telling you, that one of them is that ingenious and friendly Dr. T. C. to whose skill both you and I owe so much.

That many
times chy-
mists, by
their tedi-
ous and in-
judicious
preparati-
ons, alter
the medi-
cine, and
make it
worse.

BUT I consider farther, that as oftentimes those I am reasoning with, make use of chymical remedies, when much more easily parable ones may suffice; so in divers cases, where spagyric medicines are proper enough, their preparations of them are more tedious and expensive than is necessary. There are more than a few, who seldom prescribe, and seldomer esteem a chymical process, that is to be perfected in less than many weeks; as if a chymical medicine, like an embryo, must needs be an abortive, if it be produced in less than so many months. And as if in preparations the virtue depended less on the skilfulness, than the elaborateness, they seem to estimate the efficacy of remedies by the time and pains requisite to prepare them, and dare not think, that a medicine can quickly cure, that was not long a making; as indeed theirs (especially where cohobations and digestions, till they have such and such effects upon the matter to be wrought on by them, are prescribed) are many of them far more toilsome and tedious than those, that have but read such processes, without working them, are apt to suspect. And this is the humour of divers, not only as to those stable medicines, that ought always to be found ready in apothecaries shops, but even as to those, that are designed for particular cases, and perhaps acute diseases; in which emergencies, if a physician had no other remedies than those he must make according to such processes, it would, I fear, too often happen, that before the medicine could be ready, the patient would either be past the need of it, or past the help of it. And that, which oftentimes increaseth the tediousness of chymical processes, is the unskilful prescriptions of those, that devise them. It is not unusual in chymists writings to meet with processes, wherein the matter to be prepared, is exposed to I know not how many several successive operations: but if you should ask, why such a thing should be, for instance, rather precipitated, than exhaled *ad siccitatem*; or why such or such an operation is to be used after such another, rather than before it; nay, perhaps, if one should demand, why some of those operations should be used at all, the devisers of those unskilful processes would possibly as soon be able to finish their operations, as to give a satisfactory answer. Nay, sometimes they lengthen their processes by operations, so injudiciously prescribed, that they cross one another; and the chymist vexeth himself, and the matter he works upon, to leave it at last no better, if not a worse, medicine than he found it; of this we have already given an instance in the common magisteries.

BUT I lately met with another example of it, in the writings of a famous, modern chymist; where, to purify the fixed salt of vegetables to the height, after I know not how many solutions, filtrations and coagulations (which alone would abundantly serve the turn) he prescribes the dissolving them in aqua fortis; after which, he saith, they will

will become very pure and crystalline, and not so easily resolvable in the air: of which I make no doubt; for divers years before I met with his process, I have, with the fixed salts of more than one kind of vegetable, by joining them with aqua fortis, and after a while exhaling the superfluous moisture, made good inflammable salt-petre; by which you may easily guess, how judiciously the solution in aqua fortis is prescribed only as a farther depuration, and how fit such authors are to be credited, when they ascribe to these crystalline salts the several virtues (and those improved too) of the respective vegetables, from which the alkalies were obtained. And indeed, as to those exact depurations, which some chymists so strictly require in all their preparations, though their processes be oftentimes hereby made incredibly tedious, I will willingly allow, nay assert, that in some cases, and especially in the making of powerful menstruums, which by their activeness and penetrancy are to unlock other bodies, chymists do rather err in making their depurations less exquisite than they should, than on the other hand. Yet in many other cases, such exact refining and subtilization of a remedy is not so necessary as they imagine; and sometimes too may do more harm than good, by sequestering those parts of a simple, as *feces*, which concurred with the finer parts to that determinate texture, whereon the specific virtues of it did principally depend: but of this, more elsewhere. And therefore I shall here present you with two or three instances, to shew you, that remedies, at least as noble, as such vulgar chymical ones, as are most tedious and costly, may be prepared in a shorter time, and cheap enough to be fit for the use of the poor.

AND to comply, *Pyrophilus*, with your curiosity to know the preparations of those chymical medicines, that I do the most familiarly imploy, the three following instances shall be of such, namely, the *flores colcotharis*, the *balsamum sulphuris crassum*, and the *essentia cornu cervini*, that you may see what slight and easy preparations afford the remedies, whose effects you have so often heard of, if not also seen.

THE first of these is the same powder, which passeth under the name of *ens Veneris*; which appellation we gave it, not out of a belief, that it equals the virtues ascribed by *Helmont*, to what he calls the true *ignis Veneris*, but partly to disguise it a little, and partly upon the account of the occasion, whereon it was first found out; which was, that an industrious chymist (whom you know) and I, chancing to look together upon that tract of *Helmont's* which he calls *Butler*, and to compare it somewhat attentively with other passages of the same author, we both resolved to try, whether a medicine, somewhat approaching to that he made in imitation of *Butler's* stone, might not be easily made out of calcined vitriol: and though upon trials we found this medicine far short of what *Helmont* ascribes to his, yet finding it no ordinary one, we did, for the mineral's sake it is made of, call it *ens primum Veneris*.

THE preparation, in short, is this: Take good *Dantzick* vitriol (if you cannot get Hungarian or Goslarian) and calcine it till the calx have attained a dark-red, or purplish colour; then, by the frequent affusion of boiling, or at least warm water, dulcify it exactly: and having freed it as well as you can, from the saline parts, dry it thoroughly, and after mix it exquisitely, by grinding, or otherwise, with an equal weight of pure sal armoniack, very finely powdered. Put this mixture into a glass retort, that may be but a third part filled with it, and subliming it in a sand-furnace, by degrees of fire, for ten or twelve hours, towards the latter end increasing the fire, till the bottom of the retort (if you can) be brought to be red-hot. That which is sublimed must be taken out, and if it be not of a good yellow, but pale, (which usually

So the dissolving the salts of vegetables in aqua fortis, to make them pure and crystalline, alters their virtues, and makes them inflammable as salt-petre.

The preparation and virtues of *ens Veneris*.

usually happens for want of an exact commision of the ingredients) it may be returned to the residue, mingled better with it again, and sublimed once more. The yellow or reddish sublimate may be sublimed a second time, not from the *caput mortuum*, but by it self; but if you re-sublime it oftener, you may, though you will think that strange, impair the colour and the sublimate, instead of improving them. The dose is from two or three grains to ten or twelve (in some bodies it may be increased to twenty or thirty, without danger) in distilled water, or small-beer, or other convenient vehicles: it may be given at any time upon an empty stomach, but I most commonly give it at bed-time. It works, when it works sensibly, by sweat, and somewhat by urine. That it is a potent specifick for the rickets, I think I scarce need tell you, *Pyrophilus*, whose excellent mother and aunt, together with some physicians, to whom I also gave it ready prepared, have cured perhaps a hundred, or more, children, of that disease, divers of whom were looked upon, as in a desperate condition. I give it also in fevers, and other distempers, to procure sleep, which it usually doth, where it is wanting. In the head-ach likewise, in which, if the disease be inveterate, the remedy must be long continued; with the like admonition it hath done wonders in *suppressionē mensum obstinata*. In the worms it hath sometimes done strange things; and for provoking of appetite, I remember not, that I have either taken or given it without success. And though I seldom take (for I often give more) above two or three grains of it at a time, yet in that small dose it usually proves diaphoretical to me the next morning.

BUT the experiments we have had of the several virtues and efficacy of this medicine, would be here too tedious to recite, and therefore I shall now pass them by; though, if you require it, I shall not be backward to set you down, by way of observations, most of the cases wherein I or my friends have given it, and of the principal cures that have been performed by it. In the mean time, because this exalted colcothar, being given in so small a dose, may prove, if it be rightly and dexterously prepared, what *Helmont* saith of his imitation of *Butler's* drif, a medicine for the poor, and yet requires more care, not to say skill, to prepare it well, than by the bare reading of the process you will imagine; I shall, to gratify your charity, annex to the end of this essay (for to insert them here would make too prolix a digression) as many of the particulars relating to the preparation of it, as I can readily meet with among my loose notes. And lest you should think me a mountebank for want of knowing in what sense it is, that I commend this and the other particular medicines, I shall likewise, to those observations, subjoin a declaration of my meaning in such particulars, and of the sense, wherein I desire you should understand what you meet with in the praise of remedies, either in this essay, or any other of my writings, which I hope it will be sufficient, to give you this advertisement of, once for all.

THE next medicine, I am to mention to you, is the *balsamum sulphuris*, which being made but with gross oils, drawn by expression, may be called *crassum*, to distinguish it from the common and thinner balsam of sulphur, that is made with the distilled oil or spirit of turpentine.

THIS balsam is made in an hour or less, without a furnace, only by taking to one part of good flour of brimstone, four or five times as much (in weight) of good expressed oil, either of olives, or nuts, or poppy seeds, and boiling the former in the latter, in a pipkin half filled with both, till it be perfectly dissolved into a blood-red balsam. But as easy as this preparation seems (and indeed is) to them, that have often made it, it will not at first be so easy to make it right. For the fire, which ought to be of well kindled coals, must be kept pretty quick, and yet not

The preparation and virtues of the balsamum sulphuris crassum.

over-quick, lest the oil boil over, or do not well dissolve the flower of sulphur, but turn them with its self into a clotted and almost liver-coloured mass. And to avoid these inconveniences, and the aduotion of the matter, special care must be had to keep it constantly stirring, not only whilst the pot is over the fire, but after it is taken off, till it be quite cold. You may, if you think fit, dissolve this simple balsam in chymical oil of anise-seeds, or any other essential oil, like to advance its efficacy in this or that particular distemper; but those oils being generally very hot, I most commonly prescribe the balsam without those additions, especially if long digestion have somewhat lessened the offensiveness of the smell, which though no peculiar fault of this preparation, being common to sulphureous medicines, is yet the chief inconvenience of it. I will not resolutely affirm, that this is the very *balsamum sulphuris Rulandi*, of which that author relates such wonderful things in his Centuries; but if it be not the same, it is so like it, and so good, that I doubt not but by perusing those Centuries, you may find divers uses of it, that I have not made trial of. And in coughs, old strains, bruises, aches, (and sometimes the incipient fits of the gout itself) and especially tumours, some of your friends can inform you, that it doth much greater things, than most men would expect from so slight and easy a preparation; and indeed greater than I have seen done by very costly and commended balsams and ointments, sold in apothecaries shops. And in those observations, I lately told you, you might command, you will find, that this balsam outwardly applied hath cured such obstinate tumours, as men either knew not what to make of, or what to do with them, of which skilful physicians, to whom I gave it to make trial of in difficult cases, can bear me witness; though it ought sufficiently to endear this balsam to us both, that it was the means of rescuing your fair and virtuous sister *F.* from a dangerous consumption. In outward application it is to be well warmed, and to be chafed into the part affected, which should be afterwards kept very warm, or else lint dipt in it may be kept upon the place. Inwardly some drops of it may be given at any time, when the stomach is not full; either rolled up with sugar, or mingled with any convenient vehicle. But as for the particulars that concern the preparation of this balsam, you will find those I can readily meet with among my loose papers, annexed, with the notes concerning *ens Veneris*, to the end of this essay.

AND therefore I shall now proceed to mention the third medicine, which you have often heard of, under the name of essence of hartshorn; but which is indeed only the simple, but well purified and dephlegmed spirit of it. And though men are pleased to imagine, by the effects this remedy often produces, that I have some mysterious or elaborate way of preparing it, yet, to deal ingenuously with you, the chief thing I have done to bring it into credit, is the teaching some physicians and apothecaries a safe and easy way of making it. For whereas before, those, that went about to distil it, commonly used, as the apothecaries are wont to do in what they make of the same matter, shavings or raspings of hartshorn, and distilled it with a strong and naked fire, the fugitive and subtile spirits were wont to come over in that plenty, and with that impetuosity, as to break the glasses to pieces, whereby apothecaries, and even chymists were discouraged from drawing the spirit; and they not having it in their shops, its virtues remained unknown. Whereupon, considering, that if it were only broken on an anvil into pieces of about the bigness of one's little finger, besides that this way of comminution would be far less chargeable than rasping, the fumes would not be driven out so fast: and considering too, that a violent fire was requisite, not to distil the subtile spirit, but to drive over the gross and heavy oil; I thought it was needless to take pains to force that over, which not being (that I observed) used in physick, would cost me further pains to separate it again. And therefore, trying to

The preparation and virtues of essence of hartshorn.

distil hartshorn, in naked retorts, placed but in sand, I found I could distil two or three pound at a time, and obtain from each of them, almost, if not quite, all the spirits and volatile salt, which I afterwards separated from the reddish and lighter oil, and freed them from phelgm and feculencies by a couple of rectifications, made in tall glasses, and with very gentle heats, (commonly of a lamp-furnace.) The dose may be from eight or ten drops of the spirit, or grains of the salt, to six times the quantity of either, in warm beer, or any vehicle that is not acid, except milk. Finding it to be a medicine of an attenuating, resolving, and diaphoretical nature, and one that much resists malignity, putrefaction, and acid humours, (whence being mingled with spirit of vinegar, and the like four juices, it destroys their acidity) I direct it (*præmissis universalibus*) in fevers, coughs, pleurifies, obstructions of the spleen, liver, or womb, and principally in affections of the brain, as stoppages of the head, feverish deliriums, and even in *phrenetide*. And since I wrote a good part of this essay, I had an experiment of it in a child, who being, by many violent convulsion-fits, reduced to a desperate condition, was recovered by one dose of five or six drops of this spirit that I sent it. It is true, that I have another medicine, that is more elaborate and costly, and more properly bears the name of *essentia cornu cervi*, which I more value than this: but I cannot communicate that, without prejudicing a third person, and an excellent chymist, who makes great advantage of it. But this I can tell you, that most of the cures, for which my preparation of hartshorn hath had the good fortune to be esteemed, have been performed with the above described simple spirit and salt, with which some skilful physicians and other ingenious persons who had it from me, have within these few years saved so many lives, that I am inclined to think, I have done no useless piece of service, in bringing so happy a medicine into request, especially with those, that have skill and opportunity to make better use of it than I. But, *Pyrophilus*, I find I have detained you so long with so prolix a mention of the three above described remedies, that I should think it requisite to make you a solemn apology; but that I hope your charity will as well invite you to pardon the fault, as mine induced me to commit it.

C H A P. VII.

That mechanicks and other experimental learning may teach how to lessen the charge of cures, by making more convenient furnaces, demonstrated in divers particulars.

A FOURTH way of lessening the charges of cures may be this; that whereas the dearth of very many medicines proceeds from the chargeableness of those chymical operations, whereby they are wont to be prepared, it is to be hoped, that a greater measure of skill in physiology, and other experimental learning, will suggest cheaper and better ways of doing many things in chymistry, than are, as yet, usually practised.

AND those thrifty expedients, I conceive, may be of several kinds, of which I shall at present mention, and that but transiently, three or four.

AND first, I doubt not but chymists may be taught to make better furnaces, for several purposes, than those, that have been hitherto most used among them. For professed chymists having been for the most part unacquainted enough with many other parts of learning, and particularly with the mechanicks, their contrivances of furnaces and vessels have been far enough from being as good, as knowledge in mechanicks and dexterity in contrivances might, and, I doubt not, hereafter will, supply them with; whether as to the saving of fuel, or to the making the utmost use of the heat afforded by the fuel they do employ, or as to the intending heat to the height, or as to the regulating heat at pleasure.

It is somewhat wonderful, as well as pleasant, to see, how many vessels may be duly heated by one fire (perhaps no greater than common distillers employ to heat one vessel)

vessel) if the furnace be so contrived, as that the flame may be forced to pass in very crooked and winding channels towards the vent or vents, and the heat may be skillfully conveyed to several parts of the furnace, according to the exigency of the work it is to do. And as for the intention of heat, I remember I have had odd effects of it, by the contrivance of a certain furnace, that held but very few coals, and to which I used no bellows. But though, by this way, I could vitrify sometimes the very crucibles, and thought possibly I could, with a slight alteration, melt down the sides of the furnace themselves; yet a disciple of *Cornelius Drebell*, and a very credible person assured me, that he knew a way of furnaces, that was yet fitter to bring heat to the superlative degree; and that he himself, the relator, could by the mere force of fire in his furnace, bring Venetian talc to flow; which is more, I confess, than ever I have been able to do, either in mine, or those of the glass-house. But experience hath assured me, it is easy to make a furnace give that heat as expeditiously enough, and in other respects very conveniently to cupel both gold and silver, without the least help of bellows. That also furnaces may be so ordered, as that the heat may be better regulated, than that in our ordinary ones, I may elsewhere shew you cause to believe; and in the mean time I shall only tell you, that I look upon the skill of intending and remitting heat at pleasure, and especially the being able to keep a gentle heat long and equal, as a thing of much greater moment, both as to physick and philosophy, than chymists are wont to think, (the powerful effects of constant and temperate heats, being as yet known to few, save those, that have made trial of them.) And with lamp-furnaces well ordered, divers things may be done in imitation of nature; some friends of mine having, as several of them assure me, in such furnaces brought hen-eggs to manifest animation. That also furnaces may be so built, as to save much of the laborants wonted attendance on them, may appear by the obvious invention of athanors, or furnaces with towers, wherein the fire is for many hours, (perhaps for twenty-four, or forty-eight) supplied with a competent proportion of coals, without being able to burn much faster than it should. And that in many cases the labour of blowing may be well spared, and the annoyance of mineral fumes in great part avoided by an easy contrivance, is evident by those furnaces, which are blown by the help of a pipe, drawing the air, as they commonly speak, either at the top, as in *Glauber's* fourth furnace, or at the bottom, or for want of room, upwards, I have sometimes tried. To which may be added, that the casting of the matters to be prepared upon quick coals, as *Glauber* prescribes in that, which he calls his first furnace, is, in some cases, a cheap and expeditious way of preparing some minerals, though his method of making spirit of salt in that furnace would not succeed, according to his promise with me, and some of my acquaintance. And there are other more commodious contrivances, by casting some things upon the naked fire, which invites me to expect, that there will be several good expedients of employing the fire to chymical operations, that are not yet made use of, nor perhaps so much as dreamed of.

AND as furnaces, so the vessels, that more immediately contain the thing to be prepared, are questionless capable of being made more durable, and of being better contrived, than commonly they are. Good use may be made of those earthen retorts, that are commonly called *Glauber's* second furnaces, in case they be made of earth, that will endure strong fires, and in case there be a better way to keep in the fumes, than that he proposes of melted lead, which I have therefore often declined for another, as having found it liable to such inconveniences as I elsewhere declare.

Glass-stopples fittest for corrosive liquors.

BUT for materials that are cheap, and to be distilled in quantity, as woods, harts-horn, &c. the way is not to be despised, and is, as we may elsewhere have occasion to shew, capable of improvement; though in some cases this kind of vessel is inferior to those tubulated retorts, that were of old in use, and mentioned by *Basilus Valentinus*, and from which *Glauber* probably desumed that, which we have been speaking of. The utility of the way of sealing glasses hermetically, and of the invention, that now begins to be in request, of stopping the bottles, that contain corrosive and subtil liquors, with glass stopples, ground fit to their necks, instead of corks, together with some other things, not now to be mentioned, keep me, that I scarce doubt, but that if we could prevail with the glass-men and the potters, to make vessels of glass and earth exactly, according to directions, many things in chymistry might be done better and cheaper than now they are; and some things may be then done, that with the forms of vessels now in use cannot be done at all. And if that be true, which we find related in *Pliny*, and with some other circumstances in *Dion Cassius*, of a more ingenious than fortunate man, who, about his time, was put to death for having made malleable glass; as the truth of that story, if granted, would shew the retrieving that invention a thing not to be despaired of; so he, that could, now chymistry is so cultivated, find again the way of making glass malleable, would be, in my opinion, a very great benefactor to mankind, and would enable the virtuosi, as well as the chymist, to make several experiments, which at present are scarce practicable: and some chymists would perhaps think the attempt more hopeful, if I tell them first, that I remember *Raymund Lully* expressly reckons it among three or four of the principal virtues he ascribes to the philosopher's stone, that it makes glass malleable; and then, that an expert chymist seriously affirmed to me, that he met with an *adeptus*, who, among other strange things, shewed him a piece of glass, which the relator found, would endure and yield to the hammer. But what my own opinion is concerning this matter, and what are the (uncommon) inducements I have to be of it, I must not here declare.

That inflammable saline sulphureous spirits may be drawn from other substances cheaper than wine.

AND on this occasion, I remember I have seen an instrument of tin or pewter, for the drawing of spirit of wine (which you know is one of the chargeablest things that belongs to chymistry) so contrived, that whereas in the ordinary way much time, and many rectifications are requisite to dephlegm spirit of wine; one distillation in this vessel will bring it over from wine it self, so pure and phlegmless, as to burn all away. And I remember, that the ancient French chymist, in whose laboratory I first saw one of these instruments, told me, that it was invented not by any great alchymist or mathematician, but by a needy Parisian chirurgeon. And now I speak of spirit of wine, I shall add, that as the charges of chymistry would be very much lessened, if such ardent spirits could be had in plenty, and cheap; so I think it not improbable, that in divers places there may be found, by persons well skilled in the nature of fermentation, other vegetable substances far cheaper than wine, from which an inflammable and saline sulphureous spirit, of the like virtue, for dissolving resinous bodies, drawing tinctures, &c. may be copiously obtained. For not only it is known, that cider, perry, and other juices of fruits will afford such a spirit; and that most grains, not very unctuous, as barley, wheat, &c. will do the like, but other berries, that grow wild, as those of elder, will yield a vinous liquor. And in the *Barbadoes* they make a kind of wine, even of roots, (I mean their *Mobby*, which they make of potatoes; as I have also, for curiosity's sake, made bread of the same roots;) nay, even from some sorts of leaves, such a liquor may be obtained. For I have observed roses, well fermented, to yield a good spirit very strongly tasted, as well as inflammable. And as to the preparing of pure spirit of wine it self, I know ways (and one of them cheap)

cheap) that may exceedingly shorten the time, and pains of dephlegming it: but that being to be done otherwise, than by any peculiar contrivance of furnaces or glasses, I reserve it for a fitter place, in one of the following essays.

AND as more expedient and thrifty ways than the vulgar ones, of making chymical furnaces and vessels, may be devised; so it is to be hoped, that a skilful naturalist may find cheaper ways of heating the chymist's furnaces, or distilling in his vessels, (either by finding combustible materials, not formerly in use in the places where we work, or by making those already employed fitter for use) by bringing them, by some cheap alterations, either to give a greater, or a more durable heat; or to be less offensive by their smokes or smells; or else by discovering some cheap way of doing, in some cases, without fire, what was wont to be done by it.

Instances in divers particulars, how the naturalist may find cheaper ways of heating the chymist's furnaces.

WE see, that in some places, especially here in *England*, where charcoal was only burnt in furnaces, pit-coal is substituted in its room. And at this day there are several of those, that make aqua fortis in great quantities, that distil it with such coals, which cost nothing near so much as those made with wood. And experience hath informed me, that even in other sorts of furnaces, the same fuel may be employed, provided the bars of the grates be set wider asunder, and a little charcoal be mingled with it for the better kindling: and since of late years pit-coal have been found in several places among us, where they were not formerly known to be, it seems not improbable, that many other countries may afford chymists, and the rest of their inhabitants, the like advantage, if search were duly made, by boring of the ground, by the observations of the waters, and the steams of places suspected, and by other ways of inquiry, that a skilful man might direct. But because the abundant smoke of pit-coal uses to be very offensive, and the smaller coals easily run through the grates, and because of other inconveniences, there hath been a way found out of charring these coals, and thereby reducing them into coherent masses, of a convenient bigness and shape, and more dry and apt to kindle. And these, though quantity for quantity, their price be little inferior to that of charcoal, yet those, that consume great proportions of coals, tell me they find them almost as cheap again, in regard they will not only last much longer, but give (especially near at hand) a far more intense heat. And therefore it must be a very useful thing to chymists, to shew a way of charring sea-coals, without the help of those pots, which make them of the price they now bear. And that it is not only possible, but very easy, I could quickly shew you, if it would not prejudice an industrious laborant, whose profession being to make chymical medicines in quantity, obliges him to keep great and constant fires, and did put him upon finding a way of charring sea-coal, wherein it is, in about three hours or less, without pots or vessels, brought to charcoal; of which having, for curiosity sake, made him take out some pieces, and cool them in my presence, I found them upon breaking to appear well charr'd, and much thereof in shew not unlike a marcasite. And that, which was very convenient in this contrivance, was, that whilst the pit-coal was charring, it afforded him a very intense heat to melt or calcine the minerals, he had occasion to expose to it: And he confest to me, that by this method, he saved three parts in four of the charges the keeping such great and constant fires, with common charcoal, would cost him. In *Holland* likewise, they have a way of charring peat, (which is a combustible turf, that they dig under ground;) and a skilful distiller, that much employed it, commends it to me, as a very good fuel, even for chymical fires: which I therefore mention, because the way of charring peat is not yet brought into several countries, where peat is digged up; and probably, it would be found in divers regions, where it is yet unknown, if due search were made for it. To which I may add, that it is not unlike, that some countries

Of charring coals, so that while it chars, it gives an intense heat, fit to melt or calcine minerals.

Of charring peat.

countries may afford such combustible materials fit for chymical furnaces, as have not, as yet, been so much as named by mineralists: as I remember I have seen, and had, a sort of coals, some of which looked like marchasites, that burned clear with a good flame, and had this convenient quality for the chymist's use, that they were not apt, like the common pit-coals, to stop the grates with their cinders, but burnt to whitish ashes, almost like charcoal made of wood; and yet gave so great a heat, that an industrious chymist of my acquaintance, who kept many things constantly at work, found it worth while to have them brought him, above a day's journey on horses backs.

Of digestion and distillation without fire.

BUT it is not impossible, that when men grow better naturalists, they may find ways of exciting heat, enough for many chymical operations, without the help of fire, and consequently, without the consumption of fuel. We find, that by the attrition of hard bodies, considerable degrees of heat may be produced, not only, in combustible materials, as wood, and the like, (which would therefore be improper to be here insisted on;) but in others also, and particularly in iron and steel, one may by attrition soon produce a smart heat, as you may quickly try, by nimbly filing a piece of iron, with a rough file, or swiftly rubbing, though but a few minutes, a thin piece of steel against a board. And whether some contrivance may not be found, by the help of cheap engines moved by water, or otherwise, to produce a durable heat in iron vessels, fit to digest in, we may elsewhere have farther occasion to consider; but this is known, that from some succulent plants a liquor may be drawn, only by exposing them in glasses, purposely contrived, to the beams of the sun. And there is nothing more common, than for chymists to make their digestions by the warmth of horse-dung, whereby they might also (as some analogous trials incline me to think) conveniently enough distil some fermented liquors; especially if the way were improved by the skillful addition of quick-lime, and seasonable aspersions of water. And I doubt not, but many cheap materials might, by a few trials, be found, whereby portable digesting furnaces, without fire, (if I may so call them) might be made, without the ill smell and nastiness, which discommends the use of horse-dung. For not only we see, by what happens in the spontaneous heating of malt, and some other familiar substances, that probably most sorts of grains and berries, fit for fermentation, may be brought to yield, for a good while, a heat great enough to putrify or digest with: but I have, several years ago, by many trials found, that I could, by invironing glasses with refuse hay, well pressed down, and equally wetted throughout, produce for divers days such a heat, as made me decline the employing of horse-dung; and yet (which is the chief thing, for which I mention this) the quantity of hay was so small, that in all my trials I found not, that the hay did of it self, though kept close enough, take fire, as else is usual in ricks of hay not sufficiently dried, where the quantity, and consequently the weight, that presses the lowermost parts close together, is considerable.

Ways of distilling spirit of urine.

Of distilling it with

BUT farther, in divers operations, where an actual fire is requisite, it may be hoped, that knowing men may discover ways of saving much of the fire, and making skill perform a great part of the wonted office of heat. To obtain the spirit of fresh urine, you must distil away near nine parts of ten, which will be but phlegm, before the spirit or volatile salt will (and that scarce without a pretty strong heat) regularly rise. And there are several chymists, that to this day make use of no better way of distilling urine: but he, that knows, how putrefaction opens many bodies, may easily save himself the expence of so much fire. For if you let urine stand well stopped, for eight or ten weeks, the saline and spirituous parts will so extricate themselves, that the spirits, that before stayed behind the phlegm, will now, even with the gentlest heat, rise up first, and leave the phlegm behind. And on this occasion I shall teach you, what I do

not

not know to have been mentioned by any writer; namely, that even of fresh urine, without digestion or putrefaction, I can, by a very cheap and easy way, make subtile and penetrant spirit ascend, first, even in a gentle heat. And I am wont to do it, only by pouring urine, how fresh soever, upon quick-lime, till it swim some fingers breadth above it, and then distilling it as soon as I please. But I did not find, upon many trials, that this spirit, though even without rectification very strong and subtile, would coagulate spirit of wine, like that of putrified and fermented urine; though perhaps for divers other purposes it may be more powerful.

AND here I shall advertise you, that whereas I just now took notice, that there was a pretty strong fire requisite to force up the salt of unfermented urine out of that part, which, after the abstraction of the phlegm, remains of the consistence of honey; trial hath informed me, that the volatile salt may out of the thick liquor be obtained, better and more pure, with ease, and with a scarce credibly small heat, barely by tempering the urinous extract with a convenient quantity of good wood-ashes, whereby (for a reason elsewhere to be considered) the volatile part of the salt of urine is so freed from the grosser substance, that with strange facility it will ascend fine and white, to the top of very tall glasses. But of the differing preparation of urine, more perhaps elsewhere. I now proceed to tell you, that I think it not unlikely, that even bodies, which are more gross and sluggish, may, by the affusion of such menstruums, as human industry may find out, be far more easily, either, volatilized or unlocked, than common chymists are wont to think. For I know a liquor, not very rare among chymists, by whose help I have, often enough, distilled spirit of nitre (whose distillation requires much about the same violence of fire with that of aqua fortis) even in a moderate heat of sand, and without a naked fire. This spirit may easily enough be brought over, even in a head and body: and for a wager, I could obtain a little of it without any fire or outward heat at all. And I remember also, that having once digested a certain menstruum, for a very short time, upon crude antimony, and abstracted it, in a very gentle heat of sand; the liquor not only brought over some of the antimony in the form of red flowers, swimming in it, and united other parts of the mineral, with it self, in the transparent liquor; but the gentle heat raised to the top of the retort divers little masses of a substance, that were very transparent, like amber, which were inflammable, and finelt, and burnt blue, just like common sulphur: and yet the menstruum, which was easily again recoverable from the antimony, was no strong corrosive, tasting before it was poured on, not much unlike good vinegar.

BUT besides all the ways above mentioned of saving the chymist either time, or fire, or labour; I despair not, that divers others, yet unthought on, will be in time found out by the industry of skilful men, taking notice of the nature of things, and applying them to chymical uses; as we see, that by amalgamations with mercury, the calcination of gold and silver may be much easier performed, than by a long violence of fire. And (if it be true, what *Helmont* and *Paracelsus* tells us, of their immortal liquor alkahest) medicines far nobler, and otherwise more difficult to make, than those hitherto in use among the chymists, may be prepared with greater ease, and expedition, and with far less expence of fire, than the nature of the metals, and other concretes to be opened by it, would let a vulgar chymist suspect. However, I see no cause to doubt, that there may be menstruums found, that will much facilitate difficult operations; since, not to mention again the liquor I lately told you would work such a change on nitre, (and, I might have added, on some other compact bodies) it is very like, there may be menstruums found, that will not be so spoiled by a single operation, made with them, as our vulgar saline spirits are wont to be. For I have tried, that a menstruum, made by the bare distillation of good verdigrease, will not only draw, as

I have

lime without fermentation.

That so distilled, it doth not coagulate spirit of wine, as in the usual distillation.

Of the power of good menstruums in facilitating distillation.

That the calcination of gold is facilitated by amalgamations with mercury.

The power of verdigrease distilled, in

drawing
tinctures of
glass of an-
timony,
&c.

That the
naturalists
may find
out ways to
preserve
medicines
longer and
better than
is usual.

Of funding
liquors
with sul-
phur.

And add-
ing a little
of the white
coagulum
made of the
pure
spirits of
wine and
urine.

That the
most prin-
cipal way
of lessening
the charge
of cures
would be
the finding
out new and
more effec-
tual reme-
dies.

I have formerly told you, a tincture of glass of antimony, or perform some other like operation for once, but being drawed off from the dissolved body, or the extraction, will again serve, more than once, for the like operation upon fresh materials.

THE fifth, and last way, *Pyrophilus*, that I intend to mention, of lessening chymical expences, is, that the naturalists may probably find out ways of preserving some chymical medicines either longer or better than those ways that are usual. But of this preservation of bodies being like, as I formerly intimated, to have elsewhere further occasion to treat; I shall now only say, that the purified juices, liquid extracts, robs, and other soft medicaments, made of plants, may be conserved far cheaper, as well as better than with sugar, (which clogs most men's stomachs, and otherwise disagrees with many constitutions) in case *Helmont* say true, where he tells us, that for a small piece of money he can, for I know not how long, preserve whole barrels of liquor. And a way he intimates, of fuming liquors with sulphur, I have already told you, is a very good way of keeping them uncorrupted; provided, that (though he prescribes it not) they be six or seven several times (seldomer or oftener, according to the quantity or nature of the liquor) well impregnated with that embalming smoke; to which purpose it is convenient to have two vessels, to pour from one to the other, that whilst the liquor is shaking in the one, the other may be well filled with smoke. Whereto I shall only subjoin this secret, which a friend of mine practises, in preserving the fumigated juices of herbs, (as I elsewhere inform you, I do to preserve other things) with a success, that I have somewhat wondred at; which consists, in adding to the thick liquor to be preserved, a due, but small proportion of the white coagulum, (which I elsewhere mention) made of the pure spirits of wine and urine.

BUT I have made this excursion too prolix, and therefore I shall only add as a general admonition, that we are not, by the common practice of vulgar chymists, to estimate what knowing naturalists, skilled in mechanical contrivances, may be able in time to do, towards the making chymical remedies, as well more cheap as more effectual: and indeed, to make them more effectual, is the best way to make them more cheap.

FOR, *Pyrophilus*, after all the ways, that I have mentioned, whereby the charges of the therapeutical part of physick may be lessened; I must advertise you, both, that I make no doubt, but that there may be others found, which either through want of skill or leisure I have pretermitted, and that I have not yet named the principal of all; which is, that the deep insight into natural philosophy may qualify him, that hath it, by several ways, and especially by discovering the true causes and seats of diseases, to find out such generous and effectual remedies, (whether specifick, or more universal arcana) as by quickly freeing the patient from his disease, may exempt him from needing either much physick from the apothecary, or many chargeable visits from the doctor, or surgeon. Thus the rich merchant I mentioned, in one of the former essays, to have been freed, by a specifick, from the gout; and the young lady cured of her fistulas, by the infusion of millepedes; might well, in the ordinary way, have spent, even supposing them thrifty, an hundred times more upon physicians and physick, than the potent and nimble remedies, whereby they were so happily recovered, cost them.

[To which I shall add, by way of confirmation, both of this, and of what I lately told you, concerning the efficacy, that may be, even in slightly prepared simples, what I came to learn, since the writing of the former part of this essay; namely, that a young lady, who (though of great birth, is yet of far greater beauty and virtue, whom I presume I need not name to you) having been long troubled with an almost hereditary epileptical distemper, and after having been wearied by courses of physick prescribed

prescribed her by the famousst doctors, that could be procured, without at all mending but rather growing worse, so that sometimes she would have, in one day, eight or ten of such dismal fits, as you and I have seen her in; was cured only by the powder of true mistletoe of the oak, given as much as would lie upon a six-pence, early in the morning, in black cherry-water, or even in beer, for some days near the full moon. And I am assured, partly by the patient herself, and partly by those, that gave her the medicine, that though it had scarce any other sensible operation upon her, and did not make her sickish, especially when she slept upon it; yet after the first day she took it, she never had but one fit. And this remedy an ancient gentleman, who, being casually present, when she suddenly fell down as dead, gave it her, professed himself to have constantly cured that disease with it, when he could procure the right simple, which is here exceeding scarce. And what further experiment some friends of yours have successfully made, I may elsewhere have occasion to relate.]

An history of a radi-
cated epi-
lepsy, that
was cured,
by the pow-
der of mis-
letoe of the
oak,

To which I shall only add, that one of the skilfullest methodists I ever knew, having had much ado to preserve a young cousin of yours from a very dangerous cough, by a long course of physick; the party, at the beginning of the next winter, falling into a relapse more threatening than the first disease, was rescued from it in two or three days, by not many more takings of a specifick sent her, made of nothing else but hartshorn prepared, as I lately taught you. And if such slight medicines, consisting, each of them, but of a single simple, not elaborately prepared, may sometimes (for I say not always) perform such speedy cures even in chronical distempers; what may not be hoped from the *arcana majora* (such as *Paracelsus's Laudanum*, so praised by *Opertinus* himself, and *Butler's Driff*, so extolled by *Helmont*) when the skilfullest preparations of the noblest simples shall come to be known by learned and judicious men, intelligent in the theory of physick, and especially versed in the history of diseases? And though *Riverius* were none of the greatest naturalists, or, at least, chymists; yet if in his *Observations*, and elsewhere, he flatter not his own *Febrifugum*, how many patients did that one specifick rescue from quartans, that would else probably have proved as chargeable as tedious?

BUT, *Pyrophilus*, having said so much, that I fear you have thought it tedious, to shew, that a naturalist, skilled in chymistry and the mechanicks, may assist the physician to make his cures less chargeable, it is high time, that after so long an excursion, I proceed to consider, in what other particulars he may be a benefactor to the physician's art.

C H A P. VIII.

FIFTHLY, then, that the naturalist's skill may improve the pharmaceutical preparations of simples, by several ways partly touched already, and partly to be, either, added or farther treated of; the great variety of new remedies, wherewith the laboratories of chymists have furnished the shops of apothecaries, may convincingly inform you. To which I must take the liberty to add, (and that upon serious consideration) That the chymical preparations, hitherto common in Dispensatories, are, as to the generality of them, far enough from being the most dextrous, or noble, that can be devised. For our vulgar chymistry (to which our shops owe their venal spagyric remedies) is as yet very incomplete, affording us rather a collection of loose and scattered (and many of them but casual) experiments, than an art duly superstructed upon principles and notions, emergent from severe and competent inductions, as we have elsewhere endeavoured more particularly to manifest. And therefore, till the principles of chymistry be better known, and more solidly established, we must expect no

Other
proofs, that
the natura-
list's skill
may im-
prove the phar-
ma-
ceutical prepa-
ration of sim-
ples.

Of the best
ways to cor-
rect opium.

Of the best
way of cor-
recting of
mercurius
vite.

An excel-
lent medi-
cine made
of those
churlish
minerals,
quicksilver
and anti-
mony.

other, than that very few vulgar chymical remedies should be of the noblest sort; and that in the preparation of many others, considerable errors should be wont to pass unheeded, and faults gross enough, be apt to be mistakenly committed. But of this subject we may elsewhere have divers occasions to entertain you; and our single essay, of the *Chymical Distinctions of Salts*, will perhaps discover to you no small mistakes, in the preparation of divers applauded vulgar medicines. For it is not the elaborateness, but the skilfulness of preparations, that produceth the noble remedies; and a few teeming principles well known and applied will enable a man with ease to make better remedies, than a great many furnaces and glasses, though never so well contrived, and though very useful in their kind. To make this out in some measure, I shall name some such instances, as may withal confirm what I formerly delivered in this essay, touching the possibility and usefulness of correcting either poisonous, or otherwise very noxious simples. I never knew opium so much corrected by saffron, cinnamon, and other aromatical and cordial drugs (wherewith it is wont to be made up into laudanum) nor by the most tedious tortures of *Vulcan*, as I have known it by being a while digested in wine, impregnated with nothing, but the weight of the opium of pure salt of tartar, as we elsewhere more fully declare. (A much nobler laudanum may be made by adding to the opium, instead of the salt, two or three appropriated simples, and by due fermentations and digestions of them with it.) And for that violent vomiting-medicine, by chymists flatteringly enough called *mercurius vite*, a whole pound of cordial conserves, or liquors, will not so well moderate its evacuating force, as the keeping it continually stirring in a flattish and well-glazed earthen vessel, placed over a chaffing-dish of coals, till it emit no more fumes, but grow of a greyish colour: which I am very credibly informed to be the preparation of *mercurius vite purgans*, oftentimes mentioned and commended by the famous practitioner *Riverius*, in his *Observations*. A not unlike, but far more sudden, correction of that active powder, I elsewhere teach. And as for those operative minerals, quicksilver, and antimony, though long experience of their churlish and untractable nature has made many of the warier physicians and chymists shy to meddle with either of them single; yet these concretes, which seem so incorrigible, may, by being barely (in the gradual distillation of butter of antimony) sublimed up together in a cinnabar, and then that cinnabar, six or seven times resublimed *per se*, be united into a medicine, that not only is not wont to work, either upwards or downwards, but of which I have known safely taken, even in substance, to the dose of many grains; and a few drachms of which, infused in a pound or two of wine, hath made it of that inoffensive efficacy (taken, in the quantity of a spoonful or two, daily upon an empty stomach) that, if it still succeed as well as we have observed it two or three times to do, we may think, that our having thus acquainted you with the virtue of this unlikely remedy, (though we have also met with it, even in printed books) may make you amends for all the rest of this tedious discourse. I once knew a slight (but altogether new and tedious, as well as philosophical) preparation of salt of tartar correct and tame such poisons, as ten times the quantity of the highest vulgar antidotes, or cordials, would (I was confident) scarce have so much as weakened: and I have known by the same prepared salt, dexterously specified by simples, the virtues of some vegetables so exalted, that, without any cathartick or emetick operation, they have (if many patients, of whom I had casual opportunities to inquire of the effects of those remedies upon them, do not mis-inform me) proved more effectual in taming divers stubborn diseases, than *crocus metallorum*, *mercurius vite*, (as it is abusively called) and those other dangerous remedies, which make the vulgar wont to say of chymists, that they quickly either cure their patients, or kill them. And to let you see, *Pyrophilus*, by one plain, and yet noble instance,

that

that the knowledge of the specifick qualities of things, skilfully applied to preparations, may perform, with ease, what neither costly materials, nor elaborate processes are able to effect; give me leave to inform you, that, whereas chymists and physicians have not been able by infusing the true glass of antimony (made *per se*) in spirit of wine, or the richest cordial liquors, nor yet by torturing it after several tedious and artificial manners, to deprive it of its emetick quality; that vomitive faculty, of antimonial glass, may be corrected by so slight a way, as that of digesting it with pure spirit of vinegar, till the menstruum be highly tinged. For if you gently abstract all the liquor, and on the remaining yellow or red powder you digest well dephlegmated spirit of wine; you may after a while obtain a noble and not emetick tincture; of which though *Basilus Valentinus* prescribes but five or six drops for a dose, yet a domestick of mine having, out of curiosity, taken to the quantity of thirty drops at a time, he found it not at all vomitive. And this tincture we the rather mention, because, not only *Basilus Valentinus*, but other skilful persons, highly extol it for several diseases.

Ways to take away the vomitive faculty of antimonial glass.

See his *Currus triumphalis antimonii*.

AND let me add, *Pyrophilus*, (and be pleased to mark well what I tell you) that by bare reiterated digestions, and fermentations, there may be prepared, out of many vegetables, saline and sulphureous essences (whose bulk is exceedingly small, in proportion to the concretes whence they are extracted) which will keep many years, as I can shew you some above three years old, and contain more of the crasis (if I may so call it) of the simple, than the vulgar vegetable waters, spirits, extracts, or salts, hitherto extant in laboratories and shops. But there is so great a length of time required to the preparation of these efficacious juices, that my ambulatory condition of life hath not allowed me to furnish myself with many of them.

AND, *Pyrophilus*, if you will not disbelieve a person, for whom you have so just an esteem, as you have for that ingenious, and experienced Monsieur *L. F.* who was the French King's chymist, when you knew him at *Paris*; I can present you with a yet nobler instance, to persuade you, that, if skill be not wanting, a single herb, without any violence of fire, may, by other ways, than are in use among chymists, be easily enough brought to afford medicines, endowed with some nobler virtues than any of the most compounded, costly, and elaborate medicines, whether minerals or others, that are to be met with among vulgar chymists. This efficacious part of the plant, whence it is obtained, *Paracelsus* calls the *primum ens* of the plant, that yields it: but though, indeed, I have found the way of preparing it much plainer, and better delivered, than is usual in his writings, at the end of his book *De Renovatione & Restauratione*; yet I freely acknowledge, that I should scarce have thought it worth the trial, if it had not been for what the experienced chymist above-mentioned affirmed to me, upon his own observations, concerning it, partly, because I am not wont to be forward, so much as to try long processes upon *Paracelsus's* credit, and partly, because what he calls *Sal Solutum* seemed to me somewhat ambiguous. Since in the same page, teaching to draw the *Ens primum* of gold and antimony, he makes not use of sea-salt, but of (a salt of an incomparably higher nature) his *Sal circulatum*: and in the process immediately preceding ours, to make the *Ens primum* of emeralds, he prescribes the calcining them in *sale soluto*, which agrees far better with his *Sal circulatum*, than with any solution of sea-salt; which seems very unlikely to be able to calcine, and, as he says it must, dissolve emeralds. But the way, that our French chymist told me he used, was in substance this: Gather, in a convenient season and time of day, balm, for instance, or some other fit herb, (for experience hath taught, both him and me, that all herbs are not fit, by this way, to be reduced into liquors) and having beaten it well, in a marble mortar, to a soft mash, placed

A new and excellent way to get the *primum Ens*, or essence, of some vegetables.

The influence of these *prima Entia* to cause renovation or rejuvenescence.

in a bolt-head hermetically sealed, to digest forty days in a dunghill, or some analogous heat; then, opening the vessel, take out the matter, which will be far more liquid than before, from which, having separated the grosser parts, you must digest it in a gentle bath, that the yet remaining grosser parts may subside; to which, being filtrated, you must, according to him, (for I find not that *Paracelsus* requires it) join the fixed salt of the grosser parts above mentioned, dried and calcined. To this prepared liquor, you must add equal parts of the liquor of good sea-salt well purified, and then melted, and suffered to run *per deliquium*. This liquor, being also sealed up in a convenient glass, must be exposed to the sun for about six weeks; at the end of which time there will swim at the top of it the *primum Ens* of the plant in a liquid form, transparent, and either green or red, or, perhaps, of some other colour, according to the nature of the plant. And though *Paracelsus* prescribes but celandine, and balm, to be used, yet having inquired of our chymists, he told me, he had made such *prima Entia* of *scrophularia*, and, as I remember, of one or two other herbs. But that, which makes me thus, particularly, take notice of these kind of medicines, is, that not only *Paracelsus* ascribes to the *primum Ens* of balm, (or celandine) the power of renovating them, that use so much of it in good wine as will give it a tincture, early every morning; till, first of all the nails of their fingers, then those of their toes, afterwards their hair, and teeth, fall off; and lastly, the skin be dried and exchanged for a new one. But your ingenious acquaintance assured me several times, and once in the presence of a famous physician, and another virtuoso, to whom he appealed, as knowing the truth of what he said; that an intimate friend of his, whom he named to me, having, after the above mentioned manner, prepared the *primum Ens* of balm, to satisfy himself the better of its effects, made the trial upon himself, and took of it, according to the prescription, for about a fortnight: long before which his nails, both of hands and feet, began to loosen themselves from the skin, (but without any pain) which at length falling off, of their own accord, this gentleman keeps yet by him in a box for a rarity; but would not pursue the trial any further, being satisfied with what he had found, and being in no need of such physick. But having given of the same medicated wine, for ten or twelve days, to a woman, that served in his house, and was near seventy years of age, without letting her know, what he expected it should do; her *purgationes menstruæ* came upon her again in a sufficiently great quantity to frighten her so much, that he durst prosecute the experiment no further. And when I asked, why he made no trial upon beasts; it was answered, that though he had but little of the medicine, yet he put apart an old hen, and moistening her food with some drops of it for a week, about the sixth day she began to moult her feathers by degrees, till she became stark naked: but before a fortnight was past, she began to regain others, which when they were come to their full growth, appeared fairer, and better coloured than the first: and he added, that, besides that her crest was raised, she also laid more eggs, than she was wont. And as to the *primum Ens* of the greater *scrophularia*, by the relator himself, though he ascribed not to it any renovating power, as to that of balm or celandine; yet he assured me, he had found it ennobled by other great and extraordinary virtues. But of this kind of preparation, I might ere now possibly have been able to give you a better account, if, in my trials about them, I had not met with some unhappy accidents, which I hope my next attempts will escape: which if they do, I may possibly, with an account of them, send you one of some attempts to prepare the like medicines another and shorter way, together with a consideration, whether *Paracelsus* and others deservedly call such accidents, as the above-mentioned change of nails, hair, and even of teeth, a real renovation or rejuvenescence.

It is likewise a way of preparation, differing enough from those, that are common among chymists, which *Helmont* (as he says out of commiseration to the sick) delivers, where he teaches that, which he calls the *Via Media* of making the *Elixir Proprietatis*, of which he gives us this commendation: *Hoc medicamine tam quartanam, quam continuam statim absolvi. Aded ut qui noctu susceperat sacrosanctum viaticum, & olei extremam unctionem, me in prandio convivam circa lectum habuerit.* And though many think, that he has rather fraudulently than rightly set the process down; yet experience has invited me to absolve him in this particular. (Though I must tell you, that because a languid heat is not sufficient to make a spirituous liquor ascend, and circulate as he requires; it is not every chymist, that will, especially in his first trials, avoid the breaking of the glasses, or at least the burning of the materials, to which accidents this preparation is very obnoxious, if it be not as well watchfully as skilfully made.) And though for my part I have scarce used this elixir but as a cordial; yet I know some very expert physicians, that have given it with great success in divers difficult cases, and particularly a friend of the younger *Helmont's* gives it so successfully, that partly his patients, and partly others, that have tried it, have sometimes taken of him, at a great rate, whole pounds in a year or two; and yet I know by his own confession, that besides the skill he employs in making it dextrously, he adds nothing but one ingredient, to which, I confess, I am not apt to ascribe any considerable part of the efficacy of the medicine; which, when made, he sometimes perfumes by cohobations with musk and amber.

AND, *Pyrophilus*, that you may not wonder, that I, who think much of *Helmont's* theory scarce intelligible, and take great exceptions at many things in his writings, should yet now and then commend medicines upon his authority; I must here confess to you once for all, that (always excepting his extravagant piece, *De magnetica vulnerum curatione*) I have not seen cause to disregard many things he delivers, as matters of fact, provided they be rightly understood; having not found him forward to praise remedies without cause, though he seem to do it sometimes without measure, and having more than once, either known, or even had considerable effects of medicines he commends, which one of the happiest practitioners I have met with, and one not lavish in extolling chymical remedies has solemnly assured me, he has generally, though not always, found more than ordinarily effectual. And upon occasion of this odd preparation of the *Elixir Proprietatis*, I shall add, that, since experience shews us, by what is daily done in chymical laboratories, that upon the operation of the fire upon several concretes, substances of nature oftentimes very differing both from the body, that afforded them, and from one another, may be obtained; as the oils, and fixt salts even of cold plants, or hot; since also, by the mixture of active bodies new concretes, endowed with new qualities, may be produced; as we see, that *saccharum Saturni* emergeth from the conjunction of lead, with the acid salt, distilled vinegar; and since the same concrete, according to the differing manners, after which it is handled, may acquire differing qualities, as is clear in the various medicines, afforded us by quicksilver, and by antimony, according as each of them is ordered; I cannot but think, that if chymistry did no more than assist us, by the resolution of bodies, to extricate their more active parts, and partly by such resolutions, and partly by associating bodies together, to alter the former texture of nature's productions, or present us with new concretes of new textures; by this very means, if men want not curiosity, and industry to vary and prosecute experiments, there must necessarily arise such a store of new and active medicines, that, in all probability, many of them will be found endowed with such virtue, as have not been, at least in that degree, met with in the usual medicines, whether simple or compound, to be bought in apothecaries

In tractatulo cui titulus. Sequuntur quaedam imperfectiora.

Of *Helmont's* *Via media* of *Elixir Proprietatis*.

And the perfuming it with musk and amber.

A commendation of *Helmont's* medicines.

Of the power of chymistry.

Of the
power of
noble men-
struums
particularly.

Helm. de
febr. cap.
5. num. 26.

Helmont
de febr. c.
17. vers.
finem.

caries shops; and consequently, even without any notable discovery, or improvement of principles, chymists (even as matters now stand with them) may considerably add to the pharmaceutical part of physick. But if the operations of chymistry were seriously inquired into, and thoroughly understood, I make little doubt, but by a skilful application of them, and especially by a series of them, in a rational and orderly way, succeeding one another, there may be found out a great many preparations of remedies, both very differing from the common ones, and far more noble than they. And to make this seem probable, I need but repeat some of the examples formerly mentioned; to which I shall add now, that experience has informed me, there is a way, whereby firmer consistent substances, belonging to the bodies of animals, may, without the addition of any extraneous matter, and without any violence of heat, be reduced almost totally into liquor: and if I much misremember not, these liquors, without any violence of heat, afford their spirituous and saline parts, in a very gentle heat, and that before their phlegm. And I must peculiarly inculcate this, that if we had but a few potent menstruums, to dissolve and unlock bodies with, I scarce know what might not be done in chymistry. But when I speak of noble menstruums, I mean not such, as work like the generality of corrosives, and the like acid or saline liquors, which work but upon few kinds of bodies, and soon coagulate, or exantlate themselves by working, and thereby become unfit for future operations; but I mean such, as either are separable with all their efficacy from the dissolved body; as is said of the alkahest, or such saline or other piercing liquors, as not being precisely, either acid, urinous, or alcalizate, can dissolve a great variety of concretes, without having their virtue. I say not impaired, but destroyed thereby; and unlock mineral bodies, far more than vulgar menstruums, (as for instance by volatilizing them, or else making them irreducible, or working the like grand changes in them;) and if it be not quite separated from the dissolved body, is yet so friendly to human nature, as to be free from either fretting, or other such dangerous and offensive qualities, and rather to be of it self a powerful medicine. I should therefore exhort both you, and such other ingenious persons, as wish the advancement of chymistry, and physick, (I might possibly add natural philosophy too) to apply their chymical attempts, chiefly to the finding out of noble menstruums; for by being possessor but of one of these, a man may be able to do a great number of things, that otherwise are not to be performed. As one of our ordinary goldsmiths, by the knowledge he hath of aqua-fortis, can make many useful experiments about silver and gold, that, before that menstruum was found out all of his profession in the world were never able in many ages to compass. Nor do I much wonder at that advice, which *Helmont* gives those, that aim at the improvement of physick, in these words: *Quod si ad istud ignis arcanum non pertingatis* (he was speaking of a prodigious, not to say incredible liquor) *discite saltem, salem tartari reddere volatilem, ut hujus medio vestras solutiones perficiatis. Qui etsi sua soluta anaticè homogenea deserat, digestus in nobis; illorum tamen aliquot vires mutuatus est, quas intra desert, plurimorum morborum domitrices:* ‘But if you come not to that arcanum of *Pyrotechny*, learn at least to make the salt of tartar volatile, that by means of it you may perfect your solutions. Which though it leave those things, which it dissolveth, equally homogeneous, being digested in us; yet it borroweth some of their virtues, which it carrieth along with itself to overcome diseases.’ For concerning this salt, he not only elsewhere says, *Dicam saltem pro ingenuis, quod spiritus salis tartari, si unicornu, argentum, hydrargyrum, lapides cancerorum, vel aliquod è simplicibus dissolverit, nedum febrim, sed & plures affatim morbos sanat, &c.* ‘I will speak it for their sakes, who are ingenious, that the spirit of salt of tartar, if it dissolveth unicorn’s horn, silver, quicksilver, crabs eyes, or other

other-like simples, it will cure not only fevers, but other diseases in great abundance.' But in another place he gives us, together with some account of its way of working, this great and comprehensive commendation of it: *Mirum sanè, says he, quantum sal tartari, vel unicum, volatile factum, non præstiterit: nam omnem è venis amurcam detergit & obstruentium contumacium, dispergitque apostematum suscepta conciliabula. De hoc salis (& non olei) spiritu, verum est illud Paracelsi, quod quocunque non attigerit, vix alius potentior perveniet:* 'It is a wonder what the very salt of tartar alone being made volatile will perform; for it cleanses the veins of all the feculencies and the causes of contumacious obstructions, and doth disperse the congregated matter of apostems. Of this spirit of the salt (and not of the oil) is that saying of Paracelsus true, that whither this medicine cannot reach, there is scarce any other more powerful, that shall reach it.' These passages I should not think worth transcribing and laying together, but I find, that besides the concurrent testimonies of *Helmont*, *Paracelsus*, and *Basilus* in praise of this salt, the generality of the more inquisitive chymists, without excepting the more sober and judicious, do, by the various and painful, though fruitless attempts they have made to volatilize salt of tartar, conspire in acknowledging it a thing highly worth labouring for; nor do I for my part see (whatever some say to the contrary, and however I have indeed found it more difficult, than perhaps a novice in chymistry would think) it should be impossible; for I have more than once, with ease enough, made gold it self volatile, though it be confessed to be the fixedest body in the world, and consequently more fixed than salt of tartar, which in an open vessel may be in time made to fly away by a vehement fire. And I have likewise, by an unusual method, that I have elsewhere delivered, more than once obtained from a mixture of crude tartar, and two or three mineral bodies, good store of true volatile salt, which I could see no just cause not to think afforded by the tartar. But I must confess this may be rather a volatile salt of tartar, than salt (that is alkali) of tartar made volatile; and therefore the principal thing I mention it for, is to shew you, that tartar itself, by an unusual way of management, may be brought to afford an unusual kind of salt. But this I can tell you, that an ingenious acquaintance of mine, whom notwithstanding my wonted distrusts of chymists, I durst credit, affirmed to me, that he had himself seen a true and real *Sal tartari volatile*, made of alkali of tartar, and had seen strange things done with it, insomuch that he believed most of the things, that *Helmont* delivers of it. For my part I am inclined to think, that salt of tartar may be made volatile, (whether in the form of a sublimata or a liquor) by more ways than one, though not all of them near equally good. And whereas one of the best (if not the very best) of the ways of volatilizing it, seems to do it principally with spirit of wine, and the great difficulty of that way consists in bringing this spirit to associate with the salt; I have seen salt of tartar of my own brought to that pass, which great virtuosi have long in vain attempted to bring it unto, namely, to flow readily upon a red-hot iron, and also to take fire, and burn with a conspicuous flame, besides that when it had been dried by a smart fire, to drive away any parts, that did not firmly adhere to it, it would yet readily dissolve in high rectified spirit of wine, which you know salt of tartar will not otherwise do; not to mention the change of its alkalizate taste, and other lesser alterations: but what I can farther say of this matter, I must not declare in this place.

AND, *Pyrophilus*, that you may not be, as many other virtuosi, discouraged from labouring for noble menstruums, by the confident persuasion of many, who believe *Angelus Sala* and *Guntherus Billychius*, (whom I deny not to have been learned men, but do not take to have been great masters of chymical *Arcana*) fit to determine with authority what can, and what cannot be done by chymistry; lest, I say, you should be,

Helm. de scholar. humorista. pass. decepti. c. 2. num. 89.

The power of sal tartari volatilized.

Of the possibility of volatilizing it.

That there may be other menstruums besides such as are acid, urinous, or alkalizate.

How these
several dis-
arm and
destroy one
another,
and what
an acid
menstruum
dissolves,
an urinous
or alkali-
zate doth
precipitate.

Of a men-
struum like
to all these.

be, by such men's inconsiderate severity, brought to despair of ever seeing any noble menstruum, that is not sharp to the taste, nor of any of the three peculiar kinds of saline liquor; (acid, as aqua fortis; urinous, as the spirits of blood, urine, and other animal substances; nor alcalizate, as oil of tartar *per deliquium*;) I shall assure you, that to my own knowledge there is in the world a kind of menstruum, that consists of a pure crystalline substance, that is made by the fire, and as truly saline as salt of tartar it self; which strange salt, though well purified, and readily dissoluble, as well in dephlegmed spirit of wine, as common water, and though it be totally volatile (whence you may guess of how saline a nature it is) and also be either way reducible to a noble menstruum, does really taste sweet; I mean not in the chymical sense, by want of sourness, (as when they say, that the *calces* of corroded and precipitated things are dulcified by frequent ablutions) but by a positive sweetness. And whereas the vulgar saline menstrooms, (which alone seem to have been known to *Sala* and *Billychius*) are so specified, if I may so express it, that what an acid menstruum dissolves, an alcalizate or an urinous will precipitate, & *à converso*; and whichsoever you choose of these three sorts of menstrooms, one of the other two will disarm and destroy it; I have found by trial, not only that a red tincture of glass of antimony, being drawn with a menstruum, that was but a degree to this liquor, I could not precipitate it like our common tinctures, either with spirit of urine, or an alcalizate solution. But that (which is far more considerable) though it would readily mix with acid spirits, as oil of vitriol, with volatile and urinous spirits, as spirits of urine it self, and with alcalizate solutions; yet would neither of these three make any ebullition at all with it, or seem to work at all upon it. But of such matters, no more at present.

CHAP. IX.

That chymistry it self (much more physiology) is capable of affording a new and better methodus medendi.

YOU will perhaps expect, *Pyrophilus*, that treating of the advantages, that may accrue to the therapeutical part of physick, from a more accurate knowledge of natural philosophy, I should tell you with the chymist, that chymistry it self, and much more physiology in its full extent, is not only capable of improving the pharmaceutical part or preparations for remedies, (for that we confessed already;) but also of affording us a new and much better *methodus medendi*, or skill of using the helps, that nature or art hath provided against diseases. And indeed the physician's art is so difficult, and a man must know so many things, to be, though not tolerably, yet perfectly skilled in it, that it may, without disparagement to physicians, be thought yet capable of being improved, if not of being reformed. *Hippocrates* begins his aphorisms with a complaint, that life is short, but art long. And *Paracelsus* himself, though he say after his boasting manner, *Ars est longa, vita brevis, ubi autem donum finis* (as he speaks) *est, ibi ars est brevis, vita verum longa, si arti conferatur*: 'Art is long, life is short. But where the end is by gift, there art is short, and man's life long, if it be compared to art.' Yet expounding the same words a little above, he saith, *Itaque Hippocrates meritò de eo conqueritur: nam & affectis ipse idem accidit: ars medica consistit in philosophia, astronomia, alchymia, & physica; meritò igitur dici potest artem esse longam. Multum enim requiritur temporis, ad quatuor has columnas medicinæ discendas & perscrutandas.* 'Therefore *Hippocrates* had reason to make the complaint, for it even happened to his followers according to his words. The art of medicine consists in philosophy, astronomy, chymistry, and physicks; and therefore it may truly be said, that the art is long: for there is much time required, thoroughly to learn and search these four pillars of medicine.' *Celsus*, who hath been styled *Hippocrates Latinorum*, doth more than once call physick a conjectural art,

art, as particularly in that place, where he saith, *Est enim hæc ars conjecturalis, neque respondet ei plerumque non solum conjectura, sed etiam experientia*: 'For this art is conjectural, and not only conjecture, but experience it self doth not always answer.' And well might these great men acknowledge their art to be difficult, since the two instruments (as *Galen* calls them) of finding arts, being judgment and experience, *Hippocrates* gives this character of them; ἡ δὲ πείρα σφαιερή, ἡ δὲ κρίσις χαλεπή. 'Experience is uncertain and fallacious, judgment is difficult to be made.' And that experience may be uncertain without the theory of physick, he, that so much builds upon experiments, *Paracelsus* himself, seems to confess; where expounding the words of *Hippocrates*, he saith, *Hoc modo se habuit medicina in principio; ut nullam theoriā habuerit, sed solum experientiam hoc laxare, hoc consilipare, quomodo autem & cur, id ignoratum fuit: ideo unus salvatus est, alter perditus, nunc autem, &c.* 'And this was the fashion of medicine in the beginning, that it had no theory, only experience, that such a thing was laxative, such a thing astringent: but how, or why they were so, that was not found out; and therefore one was healed, another perished: but now, &c.' And concerning the critical part of physick (to allude to *Hippocrates's* expression) *Galen*, who exercised his reason so much about it, tells us that, *per rationem judicium haudquaquam facile existit, sed, si quid aliud, maximam habet difficultatem*: 'By reason it is not easy in a disease to give judgment, but it is as difficult as any thing imaginable.' And to affirm the difficulty of finding the best way of employing reason to the cure of diseases, not only by the authority of *Galen*, but his arguments; let me inform you, that after having told us, how difficult a thing, and how rarely to be found is that reason, which considers, and determines what on every occasion is to be done, *Neque enim* (adds he) *si veritas esset inventu facilis, tot ac tanti viri in ea querenda occupati, in tam contrarias sectas fuissent unquam dispersiti*: 'For if the truth were easy to be found, so many and so excellent men, as have made it their business to find it, had never been divided into so many sects and opinions.' And *Paracelsus*, whatever he often elsewhere boastingly affirmeth of himself, yet handsomely enough both expresseth and confesseth the difficulty of being a good physician, in one of his *Prefaces* to the Students of Physick; where he says, *Non titulus, non eloquentia, non linguarum peritia, nec multorum librorum lectio (etsi hæc non parum exornant) in medico consideranda, sed summa rerum ac mysteriorum cognitio, quæ una facile aliorum omnium vices agit. Rhetoris quidem est disertè posse loqui ac persuadere, atque judicem in suam sententiam trahere. Medici autem effectuum genera, causas ac symptōmata novisse, & iis insuper sagacitate ac industriâ pharmaca applicare, atque pro cujuslibet ingenio ac ratione vel cunctis mederi*: 'It is not a title, nor eloquence, nor skill in the tongues, nor the reading of many books (though these are ornaments) which are to be considered in a physician; but a prime knowledge of matters and mysteries, which alone may stand in the stead of all the rest. It is the part of a rhetorician to speak eloquently, to be able to persuade, and to draw the judge to his own party. It is the part of a physician to know the several sorts of diseases, their causes and symptoms, and then with skill and industry to apply medicines and to make cures of them all, according to their several natures and fashions.' But though, *Pyrophilus*, after the acknowledgments made by such great men of the almost insuperable difficulty of their art, you would perhaps think it no great presumption, if a man should attempt to innovate in any part of it, and consequently even in the *methodus medendi*: yet, *Pyrophilus*, I am much too young, too unlearned, and too unexperienced, to dare to be dogmatical in a matter of so great moment. And the physicians are a sort of men, to whose learned writings on almost all subjects, the commonwealth of learning is so much beholden, that I would not willingly dissent

In præfat.
lib. i.

In Com-
mentar.
Aphorif.
2.

Paracelsus
in his Pre-
face to his
Bertheo-
na, or Chi-
rurgia mi-
nor.

Instances to prove, that the unusual efficacies of new remedies may alter and make the method of curing more compendious; in the king's evil.

Pleurisies.

In the rickets.

from them, about those notions in their own profession, wherein they seem generally to agree; and do very much disapprove the indiscreet practice of our common Chymists and Helmontians, that bitterly and indiscriminately rail at the methodists, instead of candidly acquiescing in those manifest truths, their observations have enriched us with, and civilly and modestly shewing them their errors, where they have been mistaken. And yet, *Pyrophilus*, since divers of the eminentest methodists themselves have more than once ingeniously acknowledged to me, and seriously deplored with me, in the compleatness of their art, (which perhaps made that learned prince, the late king, tell them, that they were at best but good guessers;) and since about divers particular diseases we have observed, the method of some of the most reputed doctors of *England* (which yet, I think, is as well stored with learned men of that profession, as any part of *Europe*) not only differing, but repugnant to each other; I suppose we may, without disrespect to their profession, dissent from the most of them about those cases, about which they are reduced to disagree so much among themselves. And it would be worth an impartial disquisition, whether, since the *methodus medendi* ought to be grounded on, and accommodated to, the doctrine of diseases, the new anatomical discoveries formerly mentioned, and others not yet published, do not, by innovating divers things in pathology, require some alterations and amendments in the *methodus medendi*? But in this particular, I dare yet affirm nothing; and therefore shall proceed to observe to you, that the unusual efficacies of new remedies may probably make the method of curing more compendious, because (as I lately also intimated) one medicine may be so richly qualified, as to answer several intentions, which, in the common way, require diversity of helps and remedies. Thus, for instance, in the cure of the king's evil; by the received method, the physician must propose to himself several scopes (suited to several indications) and prosecute them successively with distinct and appropriated remedies. But I have (as I formerly also told you to another purpose) known a single specifick simple, (namely, *Paronychia folio rutaceo*) given only in small beer, in not very many days, without any sensible evacuation, waste the peccant humour, appease the pains (which before were very great) and disperse the unbroken tumours, and heal the broken ones. Thus, according to the known method, the great remedy in pleurisies is copious blood-letting, which is strictly prescribed, even to aged persons and teeming women, by the famousst of our practitioners; and, I confess, not irrationally where the physician is furnished but with vulgar remedies: and yet by some Helmontian medicines, we have known pleurisies cured even in young men, without phlebotomy, and our selves, some while since, made a successful trial of that nature in a young gentleman not unknown to you: which I mention not, with *Helmont*, to reject, or so much as to disparage phlebotomy in this disease, (for so it be moderate and seasonable, experience shews it frequently proves useful) nor, as if we observed all *Helmont*'s boasted remedies (though for the most part good ones) to be constantly successful; but to give you an instance of the truth of what I was saying before, that new and more generous remedies may so far alter the received *methodus medendi*, as to make divers of its prescriptions unnecessary. Of this truth, *Pyrophilus*, another instance might be afforded by the rickets, a new and abstruse disease, at least as is supposed; and sometimes so stubborn, that one of the famousst physicians in *Europe*, (whom I think I need not name) hath not been able of late to cure it in several of his own children. And yet, I suppose, you may have heard that excellent person, your mother, several times mention her having performed divers cures (some of them improbable enough) of this disease, barely by that slight preparation of colcothar, lately taught you, and presented her by us; and by which (we having made

made and distributed, at her desire, a considerable quantity of it) several other persons have freed children from that disfiguring sickness: of which, but few months since, your little cousin *D.* being almost past hope, was a while since brought out of danger, by God's blessing, upon some of the same remedy, wherewith we presented her mother, together with our persuasions to try it in her own child, as she had successfully done on the children of divers others. And yet this remedy (to add that upon the by, in favour of something to be said anon) works almost insensibly, save that in many bodies it is, especially at first, diaphoretick. And this property of that remedy minds me to add, that it would not be amiss for physicians, to consider, whether or no (however, bleeding, purging, vomiting, issues, glysters, scarifications, and those other painful ways of evacuation, be not, however chymists are too bitterly and undeservedly wont to reject them, to be altogether condemned and laid aside, yet) there may not in some particular diseases and bodies be found more gentle, and yet effectual ways of discharging nature of that which offends her, than those painful and debilitating ones, which we have mentioned, (without the use of one of the chief of which, namely, phlebotomy, we see that almost all kinds of diseases are cured in children.) The contributing to render the ways of cure less painful and weakening, would gratify so great a part of those, who may need physick, that I hope, you will easily pardon my spending some pages to that purpose. I consider then, that oftentimes the peccant matter, though very offensive by its qualities, is much lesser than is supposed, in quantity, and might, if we were but masters of specifick remedies, either be breathed out by insensible transpiration, or carried off by sweat or urine, without tormenting or weakening the patient, by those other copious evacuations of grosser matter, which are always troublesome and painful enough, though not always essential. Nay, that even in chirurgery it self, if those, that practise it, were as knowing as nature has been bountiful, there would not be so often a necessity, as it is commonly supposed there is, of mutilating or tormenting the patient to recover him, you cannot doubt, unless you will deny what *Gulielmus Piso* affirms, upon his own observation, of the cures done by the illiterate Indian empiricks. The passage you have seen already; but to it he adds so notable and ingenious an acknowledgement, that I cannot but honour him for it, and be willing to make way for the credibility of a good part of what we are hereafter to deliver, in this discourse by premising it: *Immo* (continues he) *ex venenatorum fungorum aliorumque toxicorum usu, solo poto infusi recentis radices Jaborandi in instanti à letho vindicatos, me aliisque Galeni nepotibus haud parum pudore suffusis, post tot alexipharmacorum & theriacalium antidotalium irritos conatus. Ita ut postea ejusmodi collegas barbaros subinde mihi adjungi passus sim, non adeo quidem nostratium valetudinem ad tactum arteriarum moderari, quam dictis modis consiliis copiam præbere solitos.* 'Nay, I saw divers, as it were in an instant, redeemed from death, who had been poisoned by the eating of venomous mushrooms and other unwholesome things, only by drinking a recent infusion of the root Jaborand, whilst my self and other of *Galen's* disciples blushed to see the ineffectual endeavours of all our alexipharmaca, treacles, and other antidotes: so that afterwards I suffered my self to be joined in consultation with those barbarous colleagues, not so much to be arbiters of the condition of our men by their pulse, as to give their assistance and counsel in the forementioned way, viz. the prescribing of proper medicines.' Thus far he: which premised, let us proceed to consider, more particularly, some of the less painful ways of freeing men from diseases.

CHAP. X.

That great cures may be done by outward applications. Francis- cus Berni- us, Don- zellinus, Ernestus Burgravi- us; who commend it upon their own experi- ence, besides very many, that com- mend it in general terms.

THAT great cures may be done by bare outward applications, you will scarce deny, if you disbelieve not the relations, which are made us, by learned men, concerning the efficacy of the *lapis nephriticus* only, bound upon the pulses of the wrists (chiefly that of the left hand) against that stubborn and anomalous disease the stone: and that, which gives the more credit to these relations, is, that not only the judicious * *Anselmus Boëtius de Boot* seems to prize it, but the famous *Monardes* professeth himself not to write by hearsay of the great virtues of this Indian stone, but to have made trial of it himself upon persons of very high quality. And that which is related by † *Monardes* is much less strange, than those almost incredible things, which are with many circumstances delivered of that stone, by the learned chymist || *Untzerus*. And although it must be acknowledged, that some stones, that go under the name, have been ineffectually applied in nephritick distempers, yet the accurate *Johannes de Laet* himself furnisheth us with an answer to that objection, informing us, that many of those nephritick stones (which differ much in colour, though the best are wont to be greenish) although not at all counterfeited, or sophisticated, are of little or no virtue. But that yet there are some others of them, which can scarce be distinguished from the former, but by trial upon nephritick persons, which are of wonderful efficacy; as he himself hath more than once tried in his own wife. *Garcias ab Orto* (Lib. 1. cap. 53.) mentions a stone, found in *Balagat*, called *Alaqueca*; of which he tells us, that though it be cheap, *Hujus tamen virtus* (to use his own words) *reliquarum gemmarum facultates exuperat, quippe qui sanguinem undiquaque fluentem illico sistat*. ‘The virtue of this stone is much above that of any other gems; for it stops ‘the flux of the blood in any part.’ *Monardes* (cap. 35.) relates the great virtues of a stone against hysterical suffocations, and concludes, *Cum uteri suffocationem imminuentem præsentiant, adbibito lapide subito levantur, & si eum perpetuo gestant (hysterici) nunquam simili morbo corripiuntur, exempla hujusmodi faciunt, ut his rebus fidem adhibeam*. ‘When the women perceive a fit of the mother coming upon them, by ‘applying this stone they are immediately eased; and if they always wear it, they are ‘never troubled with those fits more. Of this they make faith, by many instances.’ The same author, in the next chapter, treating of the *lapis sanguinaris*, or blood-stone, found in new *Spain*, (having told us, that the Indians do most confidently believe, that if the flesh of any bleeding part be touched with this stone, the bleeding will thereby be stanch’d) adds this memorable observation of his own; *Vidimus nonnullos hæmorrhoidum fluxu afflictos remedium sensisse, annulos ex hoc lapide confectos in digito continue gestando; nec non & menstruum fluxum sisti*. ‘We have seen some, that were ‘troubled with the flux of the hæmorrhoids, who found remedy by wearing rings ‘made of that stone continually on their fingers, and the monthly flux is staid by the ‘same way.’ And of the formerly mentioned *lapis porcinus*, the experienced *Bontius* (having mentioned how the Indians give the wine, wherein it hath been steeped, against the disease called *Cholera*; which is as much, and as justly feared, by the islanders of *Java*, as the plague is in *Holland*) adds this memorable passage: *Prægnantibus tamen hic lapis non bene datur; nam abortum provocare adeo certum est, fæminæ Malaicæ mibi retulerint, ut si quando menstrua eorum purgatio non bene procedat, si saltem hunc lapidem manu gestent, juvamentum se inde sentire*. ‘This stone is not proper for

* *De Lapid. & Gem. Lib. 2. cap. 11.* † *Nicolaus Monardes de simplic. Ind. Hist. 2 seu tit. 20.* † *De Nephrit. Lib. 1. c. 24.* where he hath nine or ten *Observationes raræ & inaudite de Lap. Nephritico.* Of the efficacy of *Lapis Nephriticus* and other appensa. *De Gem. & Lapidibus, Lib. 1. c. 23.*

‘ those, who are with child, for it is so sure to cause abortion, that the women of
 ‘ *Malaica* told me, that if at any time their monthly evacuations were obstructed,
 ‘ that if they only carried this stone in their hands, they found remedy thereby.’
 And the relations, *Pyrophilus*, that I may in another place present you with, concern-
 ing the wonderful stone, formerly mentioned, with which your grandfather performed
 such eminent cures, (particularly of the stone, in the Lord of *Falkland*, then deputy
 of *Ireland*, and others, to whose backs it was applied) will, I suppose, make you the
 more readily give credit to the relations of the authors we have newly mentioned.
 What *Monardes* mentions of the virtue of the *lapis sanguinaris*, to cure hæmorrhoidal
 fluxes, puts me in mind of a yet much stranger thing, which *Helmont* affirms;
 namely, that he could make a metal, of which if a ring were worn, the pain of the
 hæmorrhoids would be taken away, in the little time requisite to recite the Lord’s
 prayer; and within twenty four hours the hæmorrhoids themselves, as well internal
 as external, how protuberant soever, would vanish, and the restagnant blood would
 (as he speaks) be received again into favour, and be restored to a good condition.
 The same ring he also commends in the suffocation and irregular motion of the womb,
 and divers other diseases: but if *Paracelsus* be in any case to be credited in an un-
 likely matter, we may think, by his very solemn protestations, that he speaks upon
 his own experience, that he had a ring made of a metalline substance, by him called
electrum, (which, by his description, seems to be a mixture of all the metals joined
 together under certain constellations) which was of a far greater virtue than this of
Helmont; for *Hoc loco* (says he) *non possum non indicare admirandas quasdam vires*
virtutesque electri nostri, quas fieri his nostris oculis videmus, adeoque cum bona veritatis
conscientia proferre attestarique possumus. Vidimus enim hujus generis annulos, quos qui
induit, hunc nec spasmus convulsit, nec paralytis corripuit, nec dolor ullus torset, similiter nec
apoplexia, nec epilepsia invasit. Et si annulus hujusmodi epileptici digito annulari, etiam in
paroxysmo sævissimo, incertus fuit, remittente illico paroxysmo, æger à lapsu illico resurrexit,
&c. ‘ In this place I cannot but relate the admirable virtues of our *electrum*, which
 ‘ I have observed with my own eyes, and therefore can attest with a good conscience.
 ‘ For we saw rings of it, which he that wore neither felt cramp, nor palsy, nor other
 ‘ pain. He was subject to no fits of apoplexy, nor epilepsy, inasmuch that if one of
 ‘ these rings were put upon the ring-finger of a person actually in any vehement fit of
 ‘ the falling sickness, that fit would immediately assuage, and the person as soon
 ‘ come to himself.’ But to take notice of some other outward remedies. To our
 present theme belongs that noble cure, performed by the famous and experienced
Fabricius ab Aquapendente; who tells us, that he cured a man of a *scirrhus lienis*, and
 a dropsy, by the long use of sponges, moistened with common lime-water, and then
 expressed and worn upon the spleen; notwithstanding the muscles of the abdomen,
 and all the other parts, that lie betwixt the applied sponge and the part affected.
 And to this we may add the strange cures mentioned by *Kircherus*, and confirmed to
 me by a learned eye-witness, to be frequently performed, of very dangerous diseases,
 in that cave near *Rome*, where the patient being exposed stark naked, and tied hand
 and foot upon beds of straw; and being by the sulphureous vapour of the place, and
 sometimes their own fear, cast into a sweat, are licked well by a great number of
 peculiar kind of serpents that inhabit that grotto. Moreover, we oftentimes see agues
 cured by amulets and applications to the wrists, and I myself was, about two years
 since, strangely cured of a violent quotidian, which all the wonted method of physick
 had not so much abated, by applying to my wrists a mixture of two handfuls of bay-
 salt, two handfuls of the freshest English hops, and a quarter of a pound of blue
 currants, very diligently beaten into a brittle mass, without the addition of any thing
 moist,

Helmont. de
Febr. c. 24.

Paracelsus
in Archi-
dox. Magic.
lib.

De operat.
chirurg. p.
1. c. 15.

The cures of
 the dropsy
 and scir-
 rhus lienis
 by the ex-
 ternal ap-
 plication of
 sponges dipt
 in lime-
 water.

Of strange
 cures per-
 formed near
 Rome in
 the serpen-
 tine grotto.

moist, and so spread upon linen cloth, and tied about the wrists. And with the same remedies (which yet we have observed sometimes to fail) have divers others been cured, both of quotidian and tertian agues: nay, an eminent physician gave me, lately, thanks, for the great effects he had found of it, even in continual fevers.

Of the operations of sulphur, cantharides, quick silver, and tobacco externally applied.

Instances in divers medicines, which have differing effects inwardly given, and outwardly applied.

That preparation may much improve simples, which are outwardly applied.

AND here, *Pyrophilus*, I shall not scruple to acquaint you with my having sometimes wished, that physicians had been a little more curious to make observations and trials of the distinct operations of various bodies outwardly applied. For I consider, that, in some of them, the subtil corpuscles, (which seem to insinuate themselves into the pores of the body, and into the mass of blood, with little or no alteration) have much the like operations with the body, whence they exhale, taken in at the mouth. As we see in some preparations of sulphur, which have like virtues, inwardly given, and outwardly applied; and more manifestly in *Cantharides*, which I have found, by external application, to work strangely upon the bladder, as that they excoriated it when taken into the body; and yet more manifestly in quick-silver, which by insinuation may be made as well to salivate, as if it were swallowed down. And an eminent physician lately complained to me, that washing a child's scabby head with a decoction of tobacco, to kill and dry up the scabs, the boy was made thereby both sick and drunk. And learned men assure us, that by some catharticks outwardly applied, those may be purged, that will not swallow physick. But other medicines there are, which, before they get into the mass of blood, are much altered, either in straining through the flesh and membranes of the body, or in the digestions they pass through in the stomach, and elsewhere. And these may have very differing effects, inwardly given, and outwardly applied; as in the formerly mentioned instance of hops, currants, and salt, neither any of the ingredients inwardly given, nor the mixture hath been (that I know of) noted for any febrifugal virtues. So likewise turpentine and foot, that inwardly taken are good for quite other diseases, (as pleurisy, and obstructions of the kidneys) outwardly applied are the main ingredients of pericardiums, extolled against agues. And millefolium or yarrow, besides the virtues it hath inwardly against diseases of quite other natures, being worn in a little bag upon the tip of the stomach, was (as himself confest to me) the secret against agues, of a great lord, who was very curious of receipts, and would sometimes purchase them at very high rates. And a very famous physician of my acquaintance did since inform me, that he had used it with strange success. I know also a very happy physician, who assures me, that he hath very often cured, both in himself and others, the chilblains, when they come to be broken, by barely strowing on the fore parts the fine powder of quinces thinly sliced and dried. And who knows, what unexpected operations divers other bodies may have, when outwardly applied, if various trials of that nature were skilfully made; especially since we see, that (for reasons elsewhere to be considered) some bodies seem to have quite contrary operations, when outwardly applied and inwardly taken? For we see, that spirit of wine does, in several cases, allay the inflammation of the external parts, which given inwardly would quickly inflame the body. And our often commended *Piso*, speaking of a choice remedy for those distempers of the eyes, that used to trouble men in *Brasil*, adds, *Idem quoque præstat manipbera, ex radice mandiboca, quæ licet pota venenosa habeatur* (as we formerly noted out of his and other testimonies) *oculis tamen prodest, visumque emendat*. And if the simples, to be outwardly applied, be skilfully prepared, that may much vary and improve their operations. As we see, that vitriol, which is made of copper, or iron corroded by, and coagulated with acid salts, hath outwardly divers virtues, which crude copper has not either outwardly or inwardly. And gold dissolved in aqua regis, and

and precipitated with oil of tartar, is inwardly, as far as I can discover, gently purgative; yet the same *aurum fulminans* being calcined with twice or thrice its weight of flowers of brimstone, till the *flores* be burnt away, is known to be much commended by chymists, and others, for a diaphoretick. But though, as to any outward virtues of the same powder, physicians and chymists are wont to be silent, yet probably it may have very great ones, as well as quite differing from those it has, being taken at the mouth. For I know a person, that being grievously tormented with exulcerated hæmorrhoids, a very expert chymist of my acquaintance, not knowing what else to do, applied to the part affected an ointment consisting only of *aurum fulminans*, prepared and fixed by a slight and familiar way (which you may command) and made up with a little oil of sweet almonds into a requisite consistence; and though presently upon the application of the remedy, the pain for a quarter of an hour hugely increased, yet soon after it abated, and the hæmorrhoids the next day were closed, and the day after went away; nor has the patient ever since (that is, for some years) been troubled with any thing of relapse. And the same physician assures me, that with the like remedy he has found a strange effect in venereal ulcers. And perhaps to this may be referred what has been found by some friends of mine, that phlegm of vitriol, and *saccharum Saturni*, which not only inwardly given are said much to cool the blood, but outwardly applied are good for burns and hot humours, do yet potently discuss cold tumours. But lest you should say, that this diversity may proceed (at least in part) from the corpuscles of differing natures, that may be imagined in the fore-mentioned medicines; I shall return to what I was discoursing of before, and take notice of the efficacy of some other external remedies.

Instances in
divers pre-
parations
of gold.

An oint-
ment made
of aurum
fulminans
for the hæ-
morrhoids
and vene-
real ulcers.

[SINCE the beginning of this essay, I saw a lusty and very sprightly boy, child to a famous chymical writer, who, as his father assured me and others, being by some enemies of this physician's, when he was yet an infant, so bewitched, that he constantly lay in a miserable torment, and still refusing the breast, was reduced, by pain and want of food, to a desperate condition, the experienced relater of the story remembering, that *Helmont* attributed to the *electrum minerale immaturum Paracelsi* the virtue of relieving those, whose distempers come from witchcraft, did, according to *Helmont's* prescription, hang a piece of this noble mineral about the infant's neck, so that it might touch the tip of the stomach; whereupon presently the child, that could not rest in I know not how many days and nights before, fell for a while asleep, and waking well, cried for the teat, which he greedily sucked, from thenceforth hastily recovering, to the great wonder, both of his parents, and several others, that were astonished at so great and quick a change. And though I am not forward, to impute all those diseases to witchcraft, which even learned men father upon it; yet it is considerable in our present case, that whatsoever were the cause of the disease, the distemper was very great and almost hopeless, and the cure suddenly performed by an outward application, and that of a mineral; in which compacted sort of bodies, the finer parts are thought to be more locked up.]

The cure of
a person
effected
bewitched,
by an ap-
pended
mineral.

AMONG the proofs of the efficacy of appended remedies, we must not pretermitt the memorable examples, that are delivered by the judicious *Boetius de Boot*, concerning the virtues of that sort of jasper, which is blood-red throughout the whole body of the stone, not being mingled with any colour: *Testari possum* (says he) *me, qui alias lapidibus & gemmis tantas vires, quantas vulgus solet, non tribuo, credibile vix, de jaspidis viribus, observasse. Nam cum ancilla fluxu menstruorum ita laborasset per aliquos dies, ut nullo modo sisti posset, jaspidem rubram impositam & rudem femori alligari jussi. Alius (in eadem domo) cum in pede vulneratus esset, nec sanguinis fluxus cohiberi posset, admotu lapide, extemplo impeditus fuit, licet vulnus non tegeretur.* To these he adjoins a much.

The power
of the jas-
per to
stanch
blood.

De Lapid.
& Gem.
l. 2. cap.
102.

much more memorable example, of a maid he cured at *Prague*, who had been for six years sick of an hæmorrhagy so vehement, that there scarce ever past a week, in which she did not several times bleed, neither could she be relieved by any remedies, though she had long used them, till she was quite tired with them: wherefore our author setting them aside, lent her a jasper, of whose virtue in such cases he had made good trial, to hang about her neck, which when she did, the flux of blood presently ceased, and she afterwards, for curiosity sake, oftentimes laying aside the stone, and, as often as she needed it, applying it again, observed, that whereas the flux of blood did not presently return upon the absence of the jasper, but after divers weeks, yet upon the hanging it on again it would presently be stopt; so that she could not ascribe the relief to any thing but the stone, by which our author tells, that at length she was quite cured. And speaking of the praises given by others to green jasper speckled with red, he concludes, *Sed ego, quod multoties expertus sum, refero.* But amongst the operations of outwardly appended medicines, I have scarce met with a stranger than that, which the experienced *Henricus de Heer* mentions in the fourteenth of those observations which he truly styles rare, namely, that a woman, who had by an unskilful midwife the bladder lacerated, and thereby been subject to a perpetual *incontinentia urine*, and had been reduced constantly to wear a silver pipe, was perfectly helped, by wearing, as a gipsy had taught her, a little bag hung about her neck, containing the powder made of a live toad, burnt in a new pot. Which relation I the rather mention, not only because the author having tried the remedy upon a merchant, to whom an unskilful lithotomist had left the like disease, found it presently to succeed; but because having been very desirous to have further trial made of so odd a remedy, by a curious physician, he lately gave me this account of it, that though in one or two it had failed, yet having given some of the powder to an exquisite person, known to us both, he assured him it had succeeded in two or three. (And the disease is too unfrequent, to give occasion to have the remedy often tried.) And the physician adds, that one of those patients tells him (the physician) that though her infirmity were occasioned by a *laceratio vesicæ*, yet the remedy helps her, as long as she wears it about her, in case she renew the powder, when the virtue of it begins to decay; but that (which is remarkable to our present purpose) if she leaves it off a while, she finds the disease return. The same *Henricus ab Heer*, among his freshly commended observations, has another of a little lady, whom he concludes to have been cast into the strange and terrible distemper, which he there particularly records, by witchcraft. Upon so severe an examination of the symptoms made by himself, in his own house, that if, notwithstanding his solemn professions of veracity, he mis-relate them not, I cannot but wonder he should confidently impute so prodigious a disease to some supernatural cause. But though the observation, with its various circumstances, be very well worth your perusing; yet that, for which I here take notice of it, is, what he adds about the end of it, concerning his having cured her, after he had in despair of her recovery sent her back to her parents, by an outward medicine, namely, an ointment, which he found extolled against pains produced by witchcraft, in a Dutch book of *Carrichter's*: (where also I remember I met with it, set down a little differing from what he delivers.) Of which wonderful ointment, the ingredient that he found so extremely difficult to procure, namely, the mistletoe of hazel, being in *England* not so rare, but that I have more than once got it, and found, as he intimates, very green, and (what he mentions not) extremely bitter, I could wish, that those, that have the opportunity, would make trial. For besides what *Carrichter* delivers, and our author relates of it, a learned physician did highly commend it to the judicious *Gregorius Horsius*. And though if we allow it to cure bewitched

In Observ.
Medic. op-
pido rariss.
p. 194.
The incontin-
entia urine
cured
by the pow-
der of a
toad burnt
alive, and
hung about
the neck.

Effects
ascribed to
witchcraft,
cured per
epiphenia.

bewitched patients, the virtue, that may be in external remedies, will be made so much the more conspicuous; yet supposing the diseases to be, though strange, yet but natural, we cannot but allow, that there may be a wonderful efficacy in an outward remedy, since it was able, only by anointing the joints, and those pained parts with it, to cure a radicated disease, attended with such wonderful and horrid symptoms. And after this it may seem but little, what else would appear a strange thing, which *Helmont* affirms of a plaister he had, wherewith he tells us, that he safely cured hundreds of quartans, even autumnal, without relapse: elsewhere he saith, that he made his plaister (for by the circumstances I presume he means no other) of a few resolving and absterfive things, and adds, that it never failed him, but only that in fat persons it succeeded more slowly. And yet in these, and the like ways of curing diseases, though approved, if not also commended, by eminent physicians both ancient and modern, there is no sensible evacuation made of peccant humours, which perhaps materially remain in the body, and may, by the effluvia of these remedies, be deprived of their former qualities, and made so far obsequious to nature, that she is able, if need be, to ease her self of them by sweat, urine, or undiscerned transpiration.

Helmont
cured quartans by a
plaister.

Helmont.
de Febr.
cap. 14.
verf. finem.

Cap. 17.
in fine.

AND that the peccant humours remain for a while materially in the body (the disease sometimes being removed) may appear by the cures, which we see now and then performed of agues by sudden frights; by which no discernible evacuation is made of humours, though probably some considerable change be thereby produced in the temper of the mals of blood, or in the texture of the morbidick matter (as physicians call it;) as seems probable, both from divers other things mentioned here and there in this essay, and particularly from the lately recited passage of *Helmont*, where he takes notice of the rectifying of the peccant, and by nature rejected blood, without any sensible evacuation, upon the wearing of his ring. I knew a gentleman, a strong and resolute man, who had been long a soldier, and attained the highest sort of military employments; notwithstanding which, he was strangely fearful of rats, and could not endure the sight of them: this gentleman having been long troubled with an obstinate quartan, and travelled with it into several countries, without being able to find any cure for it, coming at length accidentally and suddenly into a place, where a great rat was in a corner, whence he could not fly from the gentleman, he furiously leaped upon him (yet without biting him) and thereby putting him into a fright, which freed him from the ague, that long had importuned him. And the experienced *Salmuth* tells us, in a pleasant observation, of one, who was cured even of the gout by a fright. For this man having his feet and hands covered with a poultis, made of turneps, flour and milk, and being left in his chair in a low room, was, whilst his servants were all gone into the garden, assaulted by a sow, who finding the door open, and invited by the smell of the cataplasim, came to devour it; and striving to do so, flung the sick man and the chair to the ground, and put him into such a fright, that our author tells us, that very day his pains decreased, and continued lessening by degrees, till at length they wholly left him, without ever returning to trouble him again. There are divers instances, that discover what great changes may be produced in the body, without taking in any thing visibly at the mouth. And on the other side, a good air alone doth often, in consumptions and other diseases, perform what hath in vain been expected from the use of emptying physick. It were to be wished, that we had, among our European physicians, the physick books of those of *China*; for though our doctors are much more learned men than theirs, yet probably their writings and their practice may teach us something that is new, and something making for our present purpose. For the famous Jesuit *Semedo* informs us,

Diseases
cured by
frights.

Observ.
Cent. 1.
Observ. 48.

Physick
now in
China is in a
good condition
without
phlebotomy,
potions, or
issues. Hist.
of *China*,
Part 1.
chap. 12.

[N. B.]

Where
practiti-
oners of
physick are
illiterate,
the speci-
ficks may
be best met
with.

Galen,
aphor.
Hipp. com-
ment.
1. The Use-
fulness of
the know-
ledge of the
medicines
of barbarous
nations.

Lib. 2.
Dialog. 7.

that the books of our physicians having not yet been brought to *China*, they are instructed in their art by abundance of their own writings; and that though in their practice they do not let blood (as the learned * *Varenius* tells us, that neither do the Japonian doctors) or set cupping-glasses, though they use no syrups, nor potions, nor any issues, but are herbalists, using nothing but herbs, roots, fruits, seeds, &c. yet physick (to use our author's words) is in a very good condition in *China*, (as *Almeida* also tells us, that the physicians are much esteemed in *Japan*;) and of the skill of some of the Chineses in that art, he gives us in the same chapter some considerable instances. And though, as we said, it is very likely, that their doctors are much inferior in point of learning to ours; yet it is considerable, that in so vast, so civilized, and so populous a country, physick can be practised with reputation, without the use of those evacuations, which are here so frequently made in phlebotomy, potions and issues. Nor should we only expect some improvement to the therapeutical part of physick, from the writings of so ingenious people as the Chineses; but probably the knowledge of physicians might be not inconsiderably increased, if men were a little more curious to take notice of the observations and experiments, suggested partly by the practice of midwives, barbers, old women, empiricks, and the rest of that illiterate crew, that presume to meddle with physick among our selves; and partly by the Indians and other barbarous nations, without excepting the people of such part of *Europe* it self, where the generality of men are so illiterate and poor, as to live without physicians. For where physick is practised by persons, that never studied the art of it in schools, or books, many things are wont to be rashly done, which, though perhaps prejudicial, or even fatal to those, on whom they are tried, may afford very good hints to a learned and judicious observer: besides, where the practitioners of physick are altogether illiterate, there oftentimes specificks may be best met with. For such persons being wont, for want of skill in physick, and particularly the art of mixing simples, and in that of varying their remedies according to circumstances, do almost wholly rely upon specificks; whose virtues, from their practice, may be sometimes better gathered, than from that of skilful physicians, in regard that those empiricks (besides that they assist not with any skill in the *methodus medendi* the virtues of their remedies) are wont, for the reasons newly mentioned, to try obstinately, and to the uttermost, the effects of their few specificks. And the nature of their medicines may be the better known, in regard they are not wont to blend them, as learned men but too often do, with many other ingredients, whose mixture, as we formerly noted, either alters their nature, or makes it difficult to determine (as *Galen* himself in a like case confesseth, *Nam, ut verum fateamur, hæc difficilis quoque res est & rara inventu, cum post multa remedia adbibita ægrotanti, quod ex iis in causa fuisse dicitur, ut melius pejusse habeat*) whether the effect be ascribed to what is given for the specifick, or to some other of the ingredients, or to the whole compound as such. The experienced *Bontius*, in his excellent little tract *de Medicina Indorum*, doth more than once confess, that it is very undeservedly, that the Europeans look upon the East-Indians as Barbarians. And even of those among them, that are ignorant of other things, he hath this passage; *Hinc etiam fit, quod homines cæteris rebus idiotæ tam exactam herbarum & stirpium nanciscantur scientiam, ut si vel doctissimus Pavius, nostri ævi botanicorum princeps, è mortuis resurgens huc veniret, miraretur se ab hisce hominibus barbaris doceri*

* *Medicines faciendæ mediocrem habent peritiam. Aegri salsa, acrida, & plura proponunt, dicente Misseo, pisces & conchyliæ pharmaca suavia & odorata. [N. B.] Sanguinem nunquam eliciunt. Magnam medicorum dignitatem videre est ex Epistola Almeida, ubi narrat, &c. Bern. Varenius, in Descript. regn. Japo... cap. 25.*

posse. And *Linschoten* in his voyages, speaking of that famous mart of the *East-Indies*, the city of *Goa*, where the Viceroy and Archbishop resided, and he himself lived: These heathenish physicians, saith he, (mentioning those of *Goa*) do not only cure their own nations and country-men, but even the Portugals also; for even the Viceroy himself, the archbishop, and all the monks and friars, do put more trust in them than in their own countrymen, whereby they get great store of money, and are much honoured and esteemed. I have not now the leisure to acquaint you with what I might alledge, to confirm this truth out of the practices of the illiterate natives of some not yet sufficiently civilized part of *Ireland*, and the inhabitants of some other places, where physicians have not yet settled: but I shall mind you of the confession of *Celsus*, where speaking of physick, *Hæc nusquam* (saith he) *non est: siquidem etiam imperitissimæ gentes herbas aliaque prompta in auxilium vulnorum morbumque noverunt.* And I wish, that other learned men would imitate the commendable example, not only of *Prosper Alpinus*, who wrote a treatise *de Medicinâ Egyptiorum*, and of *Jacobus Bontius*, in his *Medicina Indorum*, but of *Gulielmus Piso*, who hath lately presented the world with the rude way of curing, used by the *Brasilians* themselves, in his new and curious books *de Medicina Brasiliensi*, in the beginning of the second of which, he much confirms what we have been delivering, in the ensuing passage: *Quemadmodum multa in tam crassâ Barbarie cruda vel corrupta arteque hippocraticâ indigna reperiuntur, sit etiam non pauca utilissima antiquitatem redolentia, quæ vel eruditissimos medicos ad urnas medicinæ subjiciunt, observanda occurrunt. Quippe cum multarum artium rudimenta vel ab ipsis animantibus brutis (quibus benigna mater natura arte insita imprimis curandis morbis destitui noluit) ad nos redundare fatendum sit; quis dubitet ab his mortalibus, licet remotissimis à dogmaticâ & rationali medendi arte, non plurima nobilissima at secreta remedia atque antidota, medendi morbos veteribus incognitos quotidie ad posteros derivari? quibus paulatim ad manum traditis, & tandem quasi in succum & sanguinem à rationalibus converfis doctorum scholæ & libri superbiunt?* And to this agrees very well that grave saying of our experienced *Harvey*, to the very learned Doctor *Ent*: *Nulla gens tam barbara est, quæ non aut fortuito, aut inevitabili quadam necessitate coacta, aliquid in usum communem adinvenerit, quod nationes alias humaniores latuit.* Nor should we disdain the remedies of such illiterate people, only because of their being unacquainted with our theory of physick. For though I will not say, as the old empiricks wittily enough did in that passage of *Celsus*, *Requirere etiam, ratio idem doceat quod experientia, aliud?* *Si idem, supervacuum esse, si aliud, etiam contrarium.* But lest we should by too great reliance on the Galenical, or other ancient opinions, neglect useful remedies, because presented by persons, that ignore them, and perhaps too hold opinions contrary to them; I shall leave you to consider, what is in the person of the same empirical sect, represented by *Celsus*, where having spoken of the darkness of the causes of things, and the uncertainty of the theorems of physick: *Ac nihil istas cogitationes* (saith he) *ad medicinam pertinere, eo quoque disci, quod qui diversa de his senserint, ad eandem tamen sanitatem homines perduxerint. Id enim fecisse, quia non ab obscuris causis neque à naturalibus actionibus, quæ apud eos diversæ erant; sed ab experimentis, prout cuique respondeant, medendi vias traxerint, ne inter initia quidem ab istis questionibus deductam esse medicinam, sed ab experimentis, &c.* For though this sentence ascribes too little to reason, yet there is something in it, that deserves to be considered; especially since we observe not, that the late anatomical discoveries of the motions of the chyle and lymphatick liquor, by formerly unknown ways, in newly detected vessels, hath yet made men cure diseases much better than before. Not that I think, that anatomical and pathological discoveries will not, in process of time (when the *historia facti* shall be fully and indisputably made out, and the theories thereby suggested, clearly established)

Voyage, c. 34.

Preface, lib. 1.

Piso de Medic. Brasil. lib. 2. c. 1.

Georg. Ent. in Epistol. præfix. Exercit. Harvey de gen. animal.

Celsi præfatione ad Lib. 1.

A comparison of the empirick part of physick with the rational.

established) highly conduce to the improvement of the therapeutical part of physick; but yet this observation may make it the more reasonable to beware of relying so much upon the yet disputable opinions of physicians, as to despise all practices, though usually successful, that agree not with them: for of such our author speaks well, *In omnibus ejusmodi cogitationibus in utramque partem differi posse, itaque ingenium & facundiam vincere: morbos autem non eloquentiâ sed remediis curari; quæ si quis elinguis usu discreta bene norit, hunc aliquantio majorem medicum futurum, quam si, sine usu, linguam suam excoluerit.* And Paracelsus spoke well too, if he spoke truly, when in one of his prefaces, speaking to those, whom he invited to hear him expound his books of physick and chirurgery at Basil; *Illos tamen* (saith he of his formerly mentioned books) *non aliorum more ex Hippocrate aut Galeno, aut quibuscumque emendatos, sed quos summa rerum doctrina, experientia atque labore assequutus sum, proinde si quid probaturus, experimenta, ac ratio, auctororum loco, mihi suffragantur.*

Petrus de
Osma in
epist. ad
Monard.
que extat
in libello de
simplicibus
medicamen-
tis ex Occi-
dentali India
delatis.

It would, Pyrophilus, I fear, be tedious to trouble you here with all, that I have met with in good authors, applicable to my present subject, and the design I have been prosecuting in favour of external remedies: but yet one passage there is, which doth so notably confirm what we have delivered, as well touching the efficacy of simple medicines, as the great cures, that may, in divers cases, be performed by outward applications, that I must not here omit the mentioning of it; as I find the epistle written out of Peru to the inquisitive Monardes, in these words: *In urbe Posso, ubi aliquot annis vixi, omnis generis morbos Indus quidam curabat solo cujusdam plantæ succo artubus & parti affectæ illito. Ægros deinde stragulis egregiè tegebat ad sudorem provocandum: sudor è partibus illitis emanans merus sanguis erat, quem linteis pannis abstergebat, atque ita in curatione pergebat, donec satis sudasse putaret, optimis interea cibis eos alens. Eo remedio multi morbi deplorati curabantur, imo ægri juniores & robustiores ab ejus usu fieri videbantur, sed neque pretio, neque precibus, neque minis unquam efficere potuimus, ut eam plantam nobis demonstraret:* ‘In the city Posso, where I lived certain years, a certain Indian cured all sorts of diseases by the juice of one plant alone, wherewith he anointed the limbs and any other part particularly affected, and then covering them warm with blankets, provoked sweat. The sweat, that came from the part so daubed, was meer blood, which he wiped off with linnen cloths, and so he proceeded until he thought they had sweat enough. In the meantime he gave them diet, that was most nourishing. With this remedy many desperate diseases were cured, and the sick person upon the use of this physick improved, so as to appear younger and lustier after it. But we could never prevail, neither by money, nor intreaty, nor foul means, upon him to shew us the plant.’

C H A P. XI.

Of other
extraordi-
nary medi-
cines, which
work by
magnetism,
transplanta-
tion, &c.

BUT, Pyrophilus, besides such external medicines, as work after the manner of those I have heretofore mentioned, we may possibly without absurdity, provided we do it without credulity, inquire, whether there may be yet a sort of others, that operate in a more wonderful and extraordinary way? And it would not perhaps be altogether unworthy the experiment, to try, whether or no there may not sometimes be performed, such cures, as are wont to pass either for fabulous or magical; some of them being to be done without exhibiting, or applying any thing immediately to the patient, and others by some such unknown ways as those, which chymists call, either magnetism, or transplantation: such as are the cures reported to be performed by the weapon-salve and sympathetick powder, and such as is that cure of the yellow jaundice (mentioned with some verification by Paracelsus) wherein seven or nine cakes (for it must, forsooth, be an odd number) are made up with the newly emitted

and

and warm urine of the patient, and the ashes of ashwood, and buried for some days in a dunghill. For it is not only by the easy and superstitious vulgar, that the possibility of performing such cures, by transplantation, or some other magnetical way (as they pleased to call it) hath been believed. For within the compass of my own slender reading, I find, that divers eminent physicians have both made use of, and commended magnetical remedies.

WHAT is to be thought of the sympathetick powder, I confess I am as yet in doubt; but however I shall take this occasion to inform you, that a very honest gentleman, whom his pen has made known to a great part of the learned men and virtuosi in Europe, complaining often to me, that though he were much troubled with that sad disease, the stone in the bladder, yet he was more incessantly tormented with an ulcer he had in the same part, (all the searching medicines, that he took to dissolve, as he hoped, the stone, exasperating the ulcer:) I one day advised him to make use of the powder of sympathy, upon some of the ulcerous matter he voided with his urine; the remedy being such, as, if it had a magnetick virtue, might do him good; and if it had none, could not prejudice him. A while after, I received, both from him in a letter, and from his physician, very great thanks for the advice, the patient having, since the use of the powder, been eased of the distinct pain he was put to by the ulcers; and this relief lasted, if I misremember not, above a year, and how much longer I know not. But I shall not insist either upon this, or upon the testimonies and relations of Paracelsus, Helmont, Goclenius, Burgravius, nor even the modern Roman doctor, Servius, nor any of the other authors, that do professedly take upon them the defence of the weapon-salve, by reason of what we have elsewhere to write to you, by way of examination of that salve, and the sympathetick powder, that did incline me to think, that sometimes it might work upon cures. But I shall alledge something of more unexpected credit; and first Dominicus Panarola, now professor of physick at Rome, in his newly divulged *Fasciculus Arcanorum*, presents us two instances to our present purpose, in these words: *Mira* (says he) *quotidie reperiuntur in medicina ad confirmationem operis, quod doctissimus physicus, Petrus Servius* (the same we lately mentioned) *complevit de unguento armario, sciendum est quod pecia sanguine imbuta sub cineribus calidis posita menses sistit, experimento pluries comprobato: quinetiam magister meus Petrus Castellus* (whose name his late *Anatomy of the Civet Cat*, and other writings have made famous) *aiebat se expertum fuisse hæmorrhoides, si tangantur tuberosa radice chondrilla siccari, si chondrilla siccetur; corrumpi verò si corrumpatur: quapropter sub camino exsiccanda ponitur post hujusmodi tactum chondrilla tuberosa.* ‘Wonderful things are daily found out in physick to the confirmation of the operation of the learned naturalist Petrus Servius’s weapon-salve. ‘For he assured us, that a piece of cloth dipt in the blood, and put under hot ashes, ‘stops the monthly flux; the experiment having been often proved. And my master ‘Petrus Castellus affirms, as he found by experience, that the hæmorrhoids, if they ‘were touched with the tuberos root chondrilla, did dry away, if the chondrilla ‘dried, and did run to corruption, if the chondrilla was corrupted. And therefore, ‘after such touching of hæmorrhoids, the chondrilla was usually put to dry in the ‘chimney.’ The learned Salmuth, in his observations, furnishes us with an example of a most violent pain in the arm, removed by transplantation: they did beat up red corals with oaken leaves, and having kept them on the part affected ‘till suppuration, they did in the morning put this mixture into an hole bored with an augur in the root of an oak, respecting the east, and stop up this hole with a peg, made of the same tree: from thenceforth the pain did altogether cease; and when they took out the amulet, immediately the torments returned sharper than before. A great and excellent

The cure of an ulcer in the bladder by sympathetick powder.

The effects of weapon-salve, and other magnetical remedies.

Pamarola Fasc. arcan. 1.

Centur. 3. observat. 34.

excellent lady (a near kinswoman, *Pyrophilus*, of yours and mine) and very far from credulous, confessed to me, as did her servants also, that with the above-mentioned remedy of ashes and urine, she was not only once cured of the yellow jaundice, by a friend of hers, that had observed, that she had been fruitlessly vexed by a tedious course of physick, prescribed by the famousst doctor, then in *England*, but that afterwards relapsing into that same disease, she had cured herself by the same remedy. I remember, that being some years since brought almost to the brink of the grave, by a sudden effusion of blood within my body, from which, without a signal mercy of God, I should not have recovered; among other men skilled in physick that came to assist me in that danger, I was visited by a Galenist of much repute, whose pale looks inviting me to inquire, what it was that ailed him, he answered me, That he had not long before been desperately sick of an obstinate marasmus, which, notwithstanding all the remedies he could use, did daily so consume him, that he appeared but a skeleton; whereupon having found the uneffectualness of ordinary remedies, and being hopeless of being relieved by them, he resolved to try a sympathetick medicine, which I remember my self to have met with in *Hartman*. He took then an egg, and having boiled it hard in his own warm urine, he with a bodkin perforated the shell in many places, and then buried it in an ant-hill, where it was left to be devoured by the emmets; and as they wasted the egg, he found his distemper to lessen, and his strength to increase, insomuch that he now conceived his disease to have quite left him.

Observations of the transplantation of diseases. Riverius cent. 4. observ. 63.

Riverius cent. 4. observ. 19.

In historiar. & observ. 3. medico-physic. cent. 3. observ. 28.

THE experienced *Riverius* in his last observations (newly published since his death) has two notable examples to our present purpose. For first he tells us, that the eldest daughter of a great officer in *France* was so tormented with a paronychia for four days together, that the pain made her pass the night sleepless: whereupon having, by *Riverius's* order, put her finger into a cat's ear, within two hours she was delivered from her pain, and her whole hand, which before was tumid, unswelled again, except the finger, which it self was out of pain. The other case was of a counsellor's wife, who by the same remedy was cured of a panaritium (which had for four days vexed her) in a much shorter time than the other; namely, within a quarter of an hour. But that which chiefly makes these stories pertinent to our present occasion, is this notable circumstance, that in both the cases, the cat was so manifestly put to pain, that *Riverius* thought it had attracted to itself the morbidick matter, from which it freed the patient. For in the former of these two cases, the cat loudly complained of the pain he felt; and the other was, in that short time the cure was performing, put to so much pain in his ear, that two men were hardly able to hold him fast, he struggled so forcibly. And these two relations of *Riverius* may, though there be some disparity in the cases, give some countenance to what might otherwise be distrusted in the observations of the industrious *Petrus Borellus*; where he says, *Podagra mirè levatur, si catelli cum podagrigo recumbant, morbum enim contrahunt, adeò ut vix incedere queant; æger verò levamen suscipit.* 'The gout is strangely eased, if puppies lie with the person, that hath the gout; for they contract the disease so as not to be able to go, but the patient thereby finds ease.' Which perhaps he may have been induced to write, by the story that goes of that odd chymist, *Robert Fludd's* having transplanted the gout of one of his patients, by making him often sleep with a dog, that was fond of him, who thereby became subject to such periodical fits of the gout, as the master had been troubled with.

[AND since I begun this chapter, and met with these objections, discoursing of this matter with a judicious person, well skilled in physick, and whom his learned writings have made eminent, he told me, that he had, not very many months since, seen a

cure by transplantation, performed on the son of one, that was wont to make chymical vessels for me. And because the observation is considerable, that there might be no mistake in it, he has pleased to set it me down in writing (attested with his annexed name) which enables me to present it to you in his own words: *N. N.* of *N. potter*, had a son, who was long sick of the king's-evil, which swelled much, and broke into sores at last, which he could by no ordinary means heal. The old man had then a dog, which took an use of licking the sores; which the dog continued so long, till he wasted the very kernels of ulcers, that were knit in with the veins, and perfectly cured the sore, but had the swelling transplanted to himself, so that he had thereupon a great swelling, that arose and continued on his throat. The lad was thereby freed, so continued to be till 1660, and for aught I know is so this day. This I saw, being there at that time to view the clays, and bespeak retorts of the old man.*]

AND to confirm the credibility, as well as increase the number of our magnetical ways of cure; I shall add, that *Sir Francis Bacon* himself records, with great solemnity, his own having been freed, not only from very many new warts, but from one almost as old as he, by a piece of lard with the skin on it, which after having rubbed upon them, was exposed out of a southern window to putrefy. And therefore though the vanity and superstition of the authors, that speak of magnetick remedies, and the impertinent circumstances, that are usually prescribed, as necessary to their effectualness, do generally and justly enough make sober men despise, or at least suspect such unlikely ways of cure; yet in consideration of instances lately produced (to which we may perhaps elsewhere add some others) and because divers men, as well physicians as others, have seriously assured me of their having been some of them eye-witnesses, and others, performers of such cures; I am apt to think it fit, that a severe indeed, but yet further trial be made of physical experiments of this kind. And I cannot but commend the curiosity of *Dr. Harvey*, who, as rigid a naturalist as he is, scrupled not often to try the experiment mentioned by *Helmont*, of curing some tumours or excrescencies, by holding on them for a pretty while (that the cold might thoroughly penetrate) the hand of a man dead of a lingering disease; which experiment the doctor was not long since pleased to tell me, he had sometimes tried fruitlessly, but often with good success. Nor doth the grand objection against such experiments, namely, that such or such a person, having once made trial of them, found them not succeed, seem at all to me, alone, of weight enough to make such experiments, or those other improbable ones formerly mentioned, totally rejected. Because, if they really do sometimes succeed, though sometimes they chance to fail, yet that possibility of their succeeding may sufficiently evince, that there are really in nature medicines, that work after that extraordinary manner. And I see no reason, why it should be more required of those medicines, that work at distance from the patient, (or at least are not taken at mouth, or injected elsewhere) only by subtle effluvia, that they should always cure,

Cent. X.
exp. 997.

The sometimes not succeeding of magnetical medicines no sufficient cause to abandon their use.

* Some years since the present essay was written, I lighted on the 66th observation of the industrious *Bartholinus*, 3d cent. and the 53d observat. of his 6th century; in both which places giving instances of the transplantation of diseases, he mentions, besides some of those examples delivered by us, divers others; for which I am willing to refer you to the alledged places: only in the last of these observations delivering something as upon his own knowledge, (which he does not in the rest of the instances) that much confirms what we have mentioned concerning *Fludd*. We shall annex it in his own words: *In catello Milefo avi nostri materni, quem jam alit in ædibus suis avunculus meus suspiciendus M. Jacobus Finckius Phys. P. P. & academæ nostræ senior, evidentius hæc patuit trabendi facultas. Colico dolore torquebatur avunculus, canis ventri impositus, quum incalisset, argebat exitum, vomuit vehementer, & tormina colicæ avunculi remiserunt. Ancilla ejusdem in dolore dentium eundem canem genis apposuit, sensitque levamen, sed canis dolorum mispatientia hinc inde cursitare & latrare. Idem expertus est scriba in colli tumore.*

than

than it is exacted of vulgar remedies, from which we might reasonably expect more constant effects, because of their being either inwardly given, or more immediately, or at least, more durably applied to the patient. And if rhubarb be justly affirmed to be an excellent medicine in loosenesses, though we daily in *Ireland* see many swept away of those diseases, in spite of the use of rhubarb and mirabolans, with other astringent remedies to boot: and if quicksilver be, not unreasonably, by most of our physicians, esteemed and employed as an effectual remedy against venereal diseases, because it sometimes removes them, through *Fernelius*, *Montanus*, and many other learned authors tells us, as they say upon their own experience, that (though it often palliate those distempers) it very seldom cures them: nay, and if diaphoreticks are still esteemed such by the generality of physicians, though few sudorificks will cause sweat in all bodies, and scarce any in some bodies; I see not, why these remedies, that work, as it were, by emanation, may not deserve the name of medicines, if they sometimes unquestionably succeed, though they should not always prove successful ones; nor why they should, notwithstanding their sometimes not succeeding, be laid aside; especially since these sympathetical ways of cure are most of them so safe and innocent, that though, if they be real, they may do much good, if they prove fictions they can do no harm; unless by accident, as in case the patient should so singly rely on them, as to neglect (which he need not all) other helps to recover.

C H A P. XII.

Instances of
divers
cures upon
brutes, and
how these
are appli-
cable to
men.

BUT you will now perhaps demand, *Pyrophilus*, how the naturalist, as such, can contribute to the credit or advancement of the mentioned ways of curing diseases, without the wonted weakning and painful evacuations? In answer to this question, I must put you in mind, that it would be no new thing for naturalists, not professedly physicians, to treat of this subject; and that the naturalist may afford good hints to the practitioner of physick, both upon divers other accounts already touched upon, and by trying upon brutes variety of hitherto untried medicaments or remedies, and by suggesting to him both the events of such trials, and also what hath been already observed about the cures of diseases incident to beasts. For though (as we formerly told you) there are some things, that are not equally poisonous, as others not equally safe, to man, and to some brutes; yet there are other beasts, especially dogs, and monkeys, whose bodies are, by many poisons, affected almost like those of men. And since, according to the rule, *Periculum faciendum est in vili anima*, many things may be very well tried on such creatures, that we dare not at first venture to try on men; we may give dogs poisons, only to try the virtue of our antidotes; and we may give them wounds, to make trial of the efficacy of the weapon-salve and sympathetick powder: since divers of my friends (as I have intimated above) assure me, that they have some of them seen, and others performed cures of horses, lamed by pricking, by sticking the nails, that hurt them, into weapon salve; which, for that very use, among others, some of them are wont to carry about them in silver-boxes. When oxen and such like cattle are troubled with that disease, which makes them continually turn about in one place, (and is therefore called the turning-evil, or sturdy) a common remedy here in *England*, as graziers that make use of it inform me, is to cast down and tie fast the sick beast, and then to open his skull a good way, (or, if need be, take off a round piece of it over the place supposed to be affected) and at the open place to take out a little bag or bladder, which is usually found to lie near the membranes of the brain, and to be full of water and blood, and then leisurely to heal up the hurt. And this cure is much commended, as both common and easy, by our experienced *Markham*. In goats likewise, that are much subject to the dropsy,

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the husband-man ventures to slit, and let out the water under the shoulder. And divers hazardous operations in surgery, such as are arteriotomy, the exsection of the spleen, and other parts, were, or should have been first attempted upon brutes, and then practised on human bodies. And in imitation of these, it is likely, that divers other experiments, of good use in surgery, may be discovered for the relief of man, without endangering him in prosecuting such discoveries. And to say nothing of the known practice of spaying swine, and bitches; in the neighbourhood of a country-house of mine, in the west of *England*, and probably in divers other parts, some experienced shepherds have an odd way of castrating male sheep, especially lambs, when they are grown so old, that it is thought dangerous to geld them the common way. A servant of mine, that deals much in cattle, and had lately divers sheep swigged (as they call it) after this manner, tells me, that it is thus done: the beast, on whom the operation is to be performed, being held by a strong man with his belly upwards, another man draws a string, as firmly as he can (tying it with a knot or two, to prevent its yielding or slipping off) about the testicles, as if he meant, by drawing that string, to cut them off; and then anointing the part with a little fresh butter, or some such like thing, he lets the ram go to feed; which, for the most part (notwithstanding the anguish of this ligature) he will begin to do in a short time: and within two or three days, the testicles, being by the strict ligature denied the nutriment and spirits, that were wont to be conveyed to them, will grow so rotten, as either, together with the string, to fall off, or be very easily pulled off, sometimes stinking very rankly like carrion. And even among those things, that are already practised by farriers, shepherds, and graziers, there are many such things, as we have newly mentioned, which may serve either to enrich or illustrate the way of curing human bodies: their ignorance and creduloufness, together with the liberty and meanness of those creatures they physick, give them leave to venture on any thing, having made them try upon horses, and cattle, many such things, as physicians dare not try upon men and women. And among those many extravagant things, some, as it often happens, have succeeded so prosperously, as to deserve to be considered by the skilfullest physicians; some of whom might, without disparagement to their profession, do it an useful piece of service, if they would be pleased to collect and digest all the approved experiments and practices of the farriers, graziers, butchers, and the like, which the ancients did not despise, but honoured with the titles of *Hippiatrica*, and *Veterinaria*; and among which, if I had leisure, divers things may be taken notice of, which might serve to illustrate the *methodus medendi*. As to give you but one instance, which lately occurred to me, the usefulness of letting blood in some cases, which is so severely condemned by many chymists, and the efficacy of a small, if seasonable, evacuation, which can scarce be conceived to do more than alter the course of the blood, may be illustrated by the staggers in horses, and the cure of it. For I have seen a coach-horse, ready to drop down dead of his disease upon the high-way, by having his gums rubbed with the coach-whip, till the blood appeared, relieved almost in a moment so much, that though he were not well able to stand before, yet he was immediately able to go on, and draw the coach with his fellows.

C H A P. XIII.

THE next thing we are to observe to you, *Pyrophilus*, and on which its nature and importance will ingage us somewhat long to insist, is this; that the handling of physical matters was anciently thought to belong to the naturalist; as we are clearly informed by the judicious *Celsus*, in that memorable passage, where he speaking of the origin of physick, *Primo* (says he) *medendi scientia sapientiæ pars habebatur; ut morborum curatio & rerum naturæ contemplatio sub iisdem auctoribus nata sit: scilicet his hanc maxime requirentibus,*

That the handling of physical matters was anciently thought to belong to the naturalist. *Celsus* in præf. c. 1.

requirentibus, qui corporum suorum robora, inquieta cogitatione nocturnaue vigiliâ minuerant.

At the first, physick was accounted part of philosophy, so that the cure of diseases, and the contemplation of nature, did both arise under the same authors; those being most set upon medical inquiries, which had made their bodies infirm by disquieting thoughtfulness, and nocturnal watchings. He adds, that many of the professors of philosophy, especially *Pythagoras*, *Empedocles*, and *Democritus*, and that *Hippocrates* (whom some think to be the disciple of the last named) was the first, that severed physick from philosophy, and made it a distinct discipline. And this apology for the ensuing discourse being thus premised to it, I shall further answer, that I should perhaps be obliged to exceed the limits of an essay, if I should in this discourse insist on every thing, upon whose account the naturalist may assist the physician, if he be barely a *medicus* to cure diseases, which that you may the more readily believe, I shall select and prosecute some of these things in the remaining part of this essay.

That the rejecting specificicks, because they make no visible evacuation, is irrational.

AND first I shall represent to you on this subject, that the account, upon which physicians are wont to reject, if not deride, the use of such specificicks, as seem to work after a secret and unknown manner, and not by visibly evacuating peccant humours (or by other supposedly manifest qualities) being generally this; that they see not, how the promised effects can well be produced by bodies, that must work after so peculiar and undiscerned a manner; this being, I say, the great thing, that hinders physicians from endeavouring to find, or so much as being willing to make use of remedies of this sort, the naturalists may do much towards the removal of this impediment, by shewing out of such things, as may be met with or performed within the macrocosm, that such, or at least as strange operations, as are ascribed to these specificicks, are not without example in nature; and consequently ought not to be rejected, barely as being impossible. And indeed the physiology, wherewith physicians as well as others are wont to be imbued in the schools, has done many of them no small disservice, by accustoming them to gross apprehensions of nature's ways of working. Whence it comes to pass, that not a few even learned doctors will never expect, that any great matter should be performed in diseases, by such remedies, as are neither obvious to the sense, nor evacuate any gross, or at least sensible matter. Whereas, very great alterations may be wrought in a body, especially if liquid, as is the blood and peccant humour, without the ingress or egress of any visible matter, by the intestine commotion of the parts of the same body acting upon another, and thereby acquiring a differing motion, location, (if I may so speak) or figure, which, with the other qualities and effects resulting thence, may alter the motion and texture of the liquor, and thereby produce great changes in the body that harbours it. How much an unperceived recess

That great changes may be made by only misplacing, without any evacuation of the parts.

Lib. 4.
cap. 10.

The making of vinegar is an instance of this truth, especially in the Indies.

of a few subtile parts of a liquor may alter the nature of it, may be guessed at, by the obvious change of wine into vinegar; wherein upon the avolation (or perhaps but the misplacing) of so little of the spirituous and sulphureous part, that its presence, absence, or new combination with the other parts is not discernable to the eye, the scarce decreased liquor becomes of a quite differing nature from what it was. And though in *England* this degeneration be not wont to be so suddenly performed, by reason of the coldness of the climate, yet in hotter countries the change is much more speedily made. As in *Brasil*, the above mentioned *Piso* informs us, that the expressed juice of the sugar-canes, which by coction, and farther ordering, would be certainly brought to sugar, will of it self keep sweet but about four and twenty hours, and then begin to sour, and be altogether unfit to make sugar of, though very fit to turn into good vinegar. And this I find confirmed by a modern and applauded French writer, in his description of some parts of the *West-Indies*, inhabited by his nation: and relations of the same sort, concerning the hasty souring of some other liquors in *America*, I have had.

had from our English travellers and planters. And in the *East-Indies*, *Linschoten* tells us of a change much more sudden: for speaking of the formerly mentioned *Sura*, or liquor, afforded by the wounded coco tree; 'The same water (says he) standing but one hour in the sun is very good vinegar, and in *India* they have none other.' And that even very hurtful liquors (and why not then some peccant matter in the body?) may after the like manner change their nature, may appear by what we have formerly mentioned, and is unanimously affirmed by credible writers of several nations, concerning the juice of mandioca, which, being poison, when it is first expressed, does in a few hours, by fermentation, purge it self, and lose its pernicious nature. That also by the bare ingress of some subtle and not visible matter, such intestine commotions may be excited in liquors, may appear by the souring, which has been often observed upon great thunders to happen, not only to wines, but to other vinous liquors also; as I lately received from a great master of variety of liquors a complaint, that by some thunder, which happened here a few weeks since, almost all the beer and ale in the neighbourhood was spoiled. And I remember, that when I returned out of *Italy* through *Geneva*, there happened in that place an earthquake; upon which, the citizens complained, that much of their wine was soured, though I, that lodged in the highest part of the town, saw nothing to make me believe, that the bare succussion of the earth was capable to produce so great and sudden an alteration in the wine.

chap. 56.

See Pifo,
l. 2.

In the effects of
thunder
and earth-
quakes.

THAT such invisible corpuscles may pass from amulets, or other external remedies, into the blood and humours, and there produce great changes, will scarce seem improbable to him, that considers, how perishable, according to *Hippocrates*, a living body is; and that vegetable and animal bodies, whose texture is more loose and open, may well be supposed to send forth expirations, since even divers minerals are found to do the like; as may appear by the odorable steams of rubbed brimstone, and amber, by the corpuscles, which perform the magnetick operations, by the emetick quality imparted to liquors by the glass of antimony, and by *crocus metallorum* barely infused in them, without sensibly losing any thing, either of their bulk or weight; and by the virtue of killing worms, wherewith wine, and even water has been, not only by *Helmont*, but by divers other physicians, observed to be enriched, after a quantity of quick-silver has been for some hours shaken in it, though without any sensible deperdition of the substance of the mercury. And indeed I have somewhat wondered, that many learned modern physicians, either out of an affected severity, or perhaps animosity against chymists, overlook, or even deride, all operations of this nature; since I remember *Galen* himself not only confirms the like doctrine, by his reasons and authority, but delivers a very strange example of it; for, under the title of *Glychysida*, treating of peony, he thus discourses: *Est præterea omnino rescicatoria; Eapropter haud desperaverim eam ex collo pueris suspensam merito comitalem morbum sanare. Equidem vidi puellum quandoque octo totis mensibus morbo comitali liberum, ac postea fortuna cum quod à collo suspensum erat decidisset, protinus denuo convulsione correptum, rursusque suspensum in locum illius alio, inculpatè postea egisse. Porro visum est mihi satius esse rursus id collo detrakere, certioris experientiae gratiâ: id cum fecissem, ac puer iterum esset convulsus, magnam recentis radicis partem ex collo ejus suspendimus, ac deinceps prorsum sanus effectus est puer, nec postea convulsus est. Rationabile itaque erat, aut partes quaspiam à radice defluentes, ac deinde per inspirationem attrahitas, affectos ita locos curare, aut aërem à radice assidue mutari & alterari. Nam hoc pacto succus Cyrenæicus collumellam phlegmone affectam juvat, & melanthion frictum palam catarrhos & coryzas desiccant. Si quis id in calidum linteum rarum liget, assidueque calorem ex eo per inspirationem in nares attrahat. Quin etiam si pluribus linis, & maxime marinæ purpuræ, collo viperæ injectis, illis viperam præfoces, eaque postea cujuspiam collo obvincias, mirifice profueris tum paristhmiis tum omnibus iis, quæ in collo expullulant:*

Divers instances to
prove, that
invisible
corpuscles
may pass
from amu-
lets, and
cause great
alterations
in the juices
of a man's
body.

De Simp.
Med. fa-
cultatibus,
l. 6.
Galen's
example of
peony-root,
&c.

expullulant: ' Besides, it is altogether drying; and therefore I should not despair, that it, being hung about childrens necks, might cure the falling-sickness in them. I truly saw a lad, that sometimes would be eight whole months free from the falling-sickness, and then, when by chance this fell from off his neck, he became immediately surprized with a fit; and again, hanging another root in its place, he would continue well. Therefore, for experiment sake, I thought good to take it again from his neck, which when I had done, and found, that the lad fell into his former convulsions, we took a great piece of a green root, and hung it about his neck, and from that time he continued well, and felt no more convulsions. It was therefore most probable, that either certain parts did exhale from the root, and were drawn into the body by inspiration, which did so work upon the affected parts; or that the ambient air was continually changed and altered by the root: for after this manner the *succus Cyrenaicus* cures the *phlegmone* upon the *uvula*; so catarrhs and other rheums are dried up by *melanthium*, if it be tyed up warm in fine linnen, and the hot fume of it be drawn up into the nostrils by inspiration. Nay, if you strangle a viper with divers sorts of threads, and especially with the sea-purple, and then you tie those threads about the neck of your patient, you shall cure the swelling of the almonds of the ears, and all other swellings in the neck.' Nay, that such invisible bodies, by passing through grosser ones, and thereby changing the motion and nexus or juncture of their parts, may produce lasting alterations in the textures (though it be a paradox) seems not at all to me impossible. For we find the most fluid body of quicksilver has been sometimes, (I say sometimes) and therefore may, without sensible increase of bulk, be coagulated by a metalline exhalation, so as to be cut like lead, and to retain that solidity, till by some art or other it be reduced to its pristine fluidness. You may be inclined to think, that the hard and solid body of iron has a permanent alteration made in its texture, if you hold a needle during a competent time near the pole of a vigorous loadstone without touching it. For the magnetical effluvia (as may very probably be conceived) will so dispose the parts of the nearest extreme of the needle, as that they shall admit the steams, that come from one of the poles of the loadstone, and not those that come from the other: whereas by skilfully holding it to the contrary pole of the same stone, the internal pores, and consequently the texture of the needle, will presently be quite otherwise disposed, in reference to the magnetical effluvia; as we more fully declare in another essay, where we shall, I suppose, also persuade you, that the effects of the loadstone are performed by subtle bodies issuing from, or passing through it. What we have in the former discourse told you concerning our having at pleasure changed the poles of a load-stone, by help of the magnetical effluvia of the earth, may let you see, that in stones also such alterations are possible to be made. And in the next essay save one, we shall give you another instance pertinent to our purpose. For if you heat a slender piece of steel (as a graver, or the like) red hot, and suffer it to cool leisurely in the air, it will continue flexible enough, and of so soft a texture, that you may easily make impressions on it with any hardened steel: but if, instead of cooling it thus slowly, you knock it into such a dry body, as we shall there name to you, it will immediately grow so hard, as to be brittle. Which alteration, whether it be resolved to proceed from the particular effluvia of the body, into which it is knocked, or barely from the ingrels of the corpuscles of cold, (if any such there be) it will be however an instance not unfit for our purpose. And those, *Pyrophilus*, that are conversant in glass-houses, may easily observe, that glass acquires a more or less brittle texture, according as (to speak in the glass men's language) it is baked. For if, after glasses are blown, they be quickly carried into the open air, they wont to be much.

much more subject to break, than those, that after they are fashioned, are placed in a kind of very long oven, (which is wont to be built over the furnace, wherein the materials, whereof the glass is made, are kept in fusion) and are by slow degrees refrigerated, and not till after some hours exposed to the open air: for whether this difference of brittleness, and consequently of texture, be ascribed to the interrupted transcurfion of some ethereal matter, through the pores of the glass, or to the insinuations of the atoms of the cold; or to this, that the particles of the glass agitated by the heat were surprized by the cold, before they could make an end of those motions, which were requisite to their disposing themselves into the most durable texture; it is evident enough, that it is by no gross or visible body, that this permanent difference of texture is produced. Of the like to which we may elsewhere give you examples in some other concretes. That also in an human body great alterations may be made by very subtille effluvia, appears evidently, not only by the instances we have formerly given of the efficacy of some outwardly applied remedies, but by divers other things; as that many are purged by the bare odour of potions, of which I have been assured, upon his own observation, by the experienced town-physician of *Plimouth*, Dr. D. and of which *Salmuth*, in his Observations, gives us an instance in a young gentlewoman, whom he saw more happily purged by the odour of a potion, drank by her sister, than she was that took the medicine. And the same author tells us of one Dr. *Pfeil*, an eminent physician, who was wont, when he had a mind to be purged, to go into some apothecaries shop, where electuaries electively purging were preparing, to which having a while smelt, they would by their odour, after his return home, work with him six or seven times, as if he had swallowed the medicine it self. And *Henricus ab Heer*, in the twenty ninth of his formerly commended Observations, tells us of a woman, that not only was wont to be copiously purged by drinking beef-broth, but having by a fall broken her leg, used no other cathartick, than the bare odour of that sort of broth. And very observable to our purpose is the operation of the air, all along the ridge of the high mountain of *Peru*, called *Pariacaca*, of which the learned Jesuit *Joseph Acosta* relates, that though he went as well prepared as he could, to withstand the operations usually produced in travels, by that piercing air; yet when he approached to the top of the mountain, he was (notwithstanding all his provision) surprized with such fits, and pangs of striving and casting, as he thought he should cast up his heart too; having, after meat, phlegm, and choler, both yellow and green, in the end with overstriving cast up blood; and continued thus sick for three or four hours, till he had passed into a more temperate air than that of the top of the mountain; which runs about 500 leagues, and has every where, though not equally, this discomposing property, having operated upon some of his companions, as well downwards as upwards. A greater proof of the power of the steams upon the body may be taken from the propagation of infectious diseases, which being conveyed by insensible effluvia, from a sick into a healthy body, are able to disorder the whole œconomy of it, and act those sad tragedies, which physicians do so often unsuccessfully endeavour to hinder. But you will cease to doubt, that corpuscles, though so small as to be below the sense, should be able to perform great matters upon human bodies, if you consider, what alterations may be therein produced by the bare actions of the parts upon one another. This may appear by the effects of several passions of the mind, which are often excited by the bare, if attentive, thoughts of absent things. In obstinate grief and melancholy, there is that alteration made in the disposition of the heart, and perhaps some other parts, by which the blood is to circulate, that the lively motion of that liquor is thereby disturbed, and obstructions and other not easily removed distempers are occasioned..

Of purging
by the odour
of potions.

Cent. 3.
Observ. 4.

Cent. 3.
Observ. 3.

Lib. 3.
Cap. 9.

Of the
purging
and vomit-
ing quality
of the air
of the
mountain
Pariacaca.
243, 244.

The power
of steams
seen in the
infectious
effluvia.

Of alterations made by the passions of the mind.

occasioned. The bare remembrance of a loathsome potion does oftentimes produce in me (and I doubt not, but the like thought may have the like operation in many others) a horror, attended with a very sensible commotion of divers parts of my body, especially with a kind of convulsive motion, in or about the stomach. And what power the passions have to alter and determine the course of the blood, may appear yet more manifestly in modest and bashful persons, especially women, when merely upon the remembrance or thought of an unchaste, or undecent thing, mentioned before them, the motion of the blood will be so determined, as to pass suddenly and plentifully enough in the cheeks (and sometimes other parts) to make them immediately wear that livery of virtue (as an old philosopher styled it) which we call a blush. And even by joy, if great and sudden, I not long since saw in persons of both sexes, not only the cheeks and forehead, but it left (as to the lady) even the neck and shoulders dyed of that colour. And that passions may not only alter the motion of the juices of the body, but likewise make some separation and evacuation of them, may appear in grief, which is wont, especially in women, to make all the commotions requisite to weeping; whereby oftentimes a considerable quantity of briny liquor is excluded at the eyes, under the form of tears, by which divers (especially hysterical) persons are wont to find themselves much refreshed, though with some it fares otherwise in teeming women. Also that vehement desire we call longing may well be supposed to produce great alterations in the body of the mother, which leaves such strange and lasting impressions upon that of the infant; since it is the mother only, and not at all the infant, that conceives those importunate desires.

C H A P. XIV.

Divers instances of the power of imagination.

THERE are many instances to be met with in physicians books, to shew, that imagination is able so to alter the imagining person's body, as to work such a disposition in the spirits, blood and humours of it, as to produce the determinate disease that is excessively feared. And I remember, that soon after the last fair lady R. died of the small-pox, I chanced to meet one of her sisters, with her mask on, amongst some other persons of high quality, and wondering to see her sit mask'd in such company, her husband (who was present) told me, that his wife having been happily brought to bed some while before her sister fell sick, he had carefully kept the knowledge of her sickness from his wife; lest the kindness, that was betwixt them two, might prejudice her in the condition she was in: but that after a while, a lady unawares making mention in her hearing of her sister's sickness, she immediately fancied, that she should have it too, and accordingly fell sick of that disfiguring disease, whose marks obliged her for a while to wear a mask. Nor is it in women only, but even in men, that conceit may produce such real and lasting effects. For many authentick histories record examples of those, in whom excessive grief or fear has made such a change in the colour of their hair in a night, as nature would otherwise have scarce made in divers years. And I remember, that being about four or six years since, in the county of *Cork*, there was an Irish captain, a man of middle age and stature, who coming with some of his followers to render himself to your uncle *Broghill*, who then commanded the English forces in those parts, upon a publick proffer of pardon to the Irish, that would then lay down their arms, he was casually, in a suspicious place, met with by a party of the English, and intercepted. And my brother being then absent upon a design, he was so apprehensive of being put to death by the inferiour officers, before your uncle's return, that that anxiety of mind quickly changed the colour of his hair after a peculiar manner: of which I (being then at that castle of your uncle's, whereunto he was brought) had quickly notice

An instance of the hair of the head changed in colour upon a sudden fear.

notice given me, and had the curiosity to examine this captain, and found, that the hair of his head, had not (as in the instances I had met with in histories) uniformly changed its colour, but that here and there certain peculiar tufts and locks of it, whose bases might be about an inch in diameter, were thus suddenly turned white all over: the rest of his hair (of which you know the Irish use to wear good store) retaining its former reddish colour.

[You will mistake my design, *Pyrophilus*, if you conclude from what I have said, concerning the power of effluvia to work upon the body, that I am either so much an Helmontian, as to condemn the use of all those remedies, that make such more gross evacuations (if I may so call them) as are made by vomit, siege, and the like; or that I would have you, or am my self so credulous, as to believe all the virtues, that are even by eminent writers ascribed to the remedies called Specificks. For (to mention here but this) we have observed, that the hopes built upon even excellent specificks, unless they be of such a resolving and absterfivè nature, as to be able to make way for themselves into the recesses of the body, are oftentimes disappointed, where some emetick or cathartick remedy has not been first used to free the stomach and guts from those viscous humours, which obstructing the first passages, much enervate the virtue of the remedy, if they do not altogether deny it access to the innermost parts of the body. That then, which I aim at, is first to keep you from being prejudiced by the confidence of some learned doctors, who laugh at the very name of specificks, and will not allow any disease to be curable, but by visible evacuations of store of what they call peccant matter; and next to give you cause to think, that such specificks, as men of judgment and credit do recommend upon their own experience, ought not to be rejected without trial, upon the bare account of their not being either laxative or vomitive, sudorifick, or diuretical; nay, not so much as for this, that they are not endowed with any eminent degree of any manifest quality, such as heat, cold, dryness, odour, taste, astriction; and the like; nor able perchance to work any considerable alteration in a healthy human body. For I consider the body of a living man, not as a rude heap of limbs and liquors, but as an engine consisting of several parts so set together, that there is a strange and conspiring communication betwixt them, by virtue whereof, a very weak and inconsiderable impression of adventitious matter upon some one part may be able to work on some other distant part, or perhaps on the whole engine, a change far exceeding what the same adventitious body could do upon a body not so contrived. The faint motion of a man's little finger upon a small piece of iron, that were no part of an engine, would produce no considerable effect; but when a musket is ready to be shot off, then such a motion being applied to the trigger by virtue of the contrivance of the engine, the spring is immediately let loose, the cock falls down, and knocks the flint against the steel, opens the pan, strikes fire upon the powder in it, which by the touch-hole fires the powder in the barrel, and that with great noise throws out the ponderous leaden-bullet, with violence enough to kill a man at seven or eight hundred foot distance. And that also the engine of an human body is so framed, as to be capable of receiving great alterations from seemingly slight impressions of outward objects, upon the bare account of its particular contrivance, may appear by several instances, beside those, which may belong to this argument in the foregoing part of this essay. When a man goes suddenly out into the sun, it often happens, that those beams, which light upon the head, and would not in so short a time have any discernible effect on the least hair of it, do almost in a moment produce that strange and violent motion in the head, and almost all the body, which we call sneezing. Men, that from the top of some pinnacle, or other high and steep place, do look down to the bottom of it, are at first

How the author's discourse concerning the power of effluvia ought to be understood.

That the particular state and disposition of the engine of an human body is considerable as to the effects of these impressions.

very

very apt, by the bare prospect, (which yet conveys nothing into the body, but those images, if yet there intervene corporeal ones in sensation of visible objects, that enter the eye) to become so giddy, that they are reduced to turn away their eyes from the precipice, for fear of not being able to stand upon their legs. And many, that looked fixedly upon a whirlpool, or upon a very swift stream, have had such a vertiginous motion thereby impressed on their spirits, that they have been unable to keep their bodies upright, but have fallen into the water they gazed on. And it is no less remarkable, that when a man is somewhat discomposed at sea, and yet not enough to vomit freely; the seamen are wont to advise him to look from the side of the ship upon the water, which seeming swiftly to pass by the vessel, has upon the gazer the operation of a rapid stream, and by making him giddy, hastens and facilitates his vomiting; as I have sometimes tried upon my self, when I had a mind for health's sake to be put into a fit of sea-sickness. If a person be very ticklish, and you but gently stroke the sole of his foot with the top of a feather, that languid impression on the bottom of the foot shall, whether he will or no, put all those muscles and other parts into motion, which are requisite to make that noise, and to exhibit that shape of the face (so far distant from the feet) which we call laughing; and so the gentle motion of a straw, tickling the nostrils, is able to excite sneezing. Most men may observe in themselves, that there are some such noises, as those made by the grating of an ungreased cart-wheel upon the axle-tree, or the tearing of coarse paper, which are capable of setting the teeth on edge, which yet cannot be done without exciting a peculiar motion in several parts of the head. I had a servant, who sometimes complained to me of a much more remarkable and unfrequent disorder; namely, that when he was put to whet a knife, that stridulous motion of the air was wont to make his gums bleed. *Henricus ab Heer* (in his twenty ninth observation) records a story of a lady, to whom he was sent for, who upon the hearing of the sound of a bell, or any loud noise, though singing, would fall into fits of sounding, which was scarce distinguishable from death; and we may confirm, that this disposition depended upon the texture of her body, in reference to material sounds, by what he subjoins, that having well purged her, and giving her for two months the *Sparw-waters*, and other appropriate remedies, he thoroughly cured her. And it often enough happens, that when a woman is in a fit of the mother, another hysterical person standing by is, by reason of a peculiar disposition of her body, soon infected with the like strange discomposure. And to shew you, that a distempered body is both an engine, and also an engine disposed to receive alterations from such impressions as will make none on a sound body, let me put you in mind, that those subtle steams, that wander through the air before considerable changes of weather disclose themselves, are wont to be painfully felt by many sickly persons, and more constantly by men, that have had great bruises or wounds, in the parts that have been so hurt; though neither are healthy men at all incommodated thereby, nor do those themselves, that have been hurt, feel any thing in those sound parts, whose tone or texture has not been altered or enfeebled by outward violence. I have known several also (and the thing is obvious) whose bodies and humours are so framed and constituted, that if (as men commonly speak) they ride backward in a coach, that motion will make them giddy, and force them to vomit. And it is very ordinary for hysterical women to fall into such fits as counterfeit epilepsies, convulsions, and I know not what violent distempers, by the bare smell of musk and amber, and other strong perfumes, whose steams are yet so far from having great, much less such effects in other human bodies, that almost all men, and the generality even of healthy women, are not affected by them, unless with some innocent delight. And that even on men, odours (how minute

minute and invisible bodies soever) may sometimes have very great power, may be gathered from the story told us by *Zacutus Lusitanus*, of a fisherman, who having spent all his life at sea, and being grown old there, and coming to gaze upon a solemn reception made in a maritime town, to *Sebastian* king of *Portugal*, was, by the perfumes plentifully burnt, to welcome the king, immediately cast upon the ground thereby into a fit, which two physicians judged apoplectical, and physicked him accordingly, till three days after the king's chief physician, *Thomas à Vega*, guessing at the cause of the disease, commanded him to be removed to the sea-side, and covered with sea-weeds, where, within four hours, the maritime air and steams began to open his eyes, and made him know those, that were about him, and within not many days restored him to health. We may also conjecture, how much the alteration produced in the body by sickness may dispose it to receive strong impressions from things, that would not otherwise much affect it, by this; that even a man in perfect health, and who is wont to drink cold liquor without the least harm, may, when he has much heated himself by exercise, be cast by a draught of cold drink into such sudden, formidable and dangerous distempers, as, did not daily experience convince us, we should scarce think possible to be produced in a body, free from morbid humours, by so familiar a thing as a cup of small-beer or water: infomuch that *Benivenius* relates a story of one, who after too vehement exercise drinking a glass of very cold water fell into a swoon, that was quickly succeeded by death. And yet, to add that, on this occasion, in bodies otherwise disposed, a large draught of cold water, drunk even without thirst, may very much relieve the drinker, and prevent great fits of the mother, and partly of the spleen, especially upon sudden frights; to which purposes, I know some hysterical ladies, that find in this remedy, as themselves assure me, more advantage, than one would easily imagine.

In Pr. med.
adm. l. 3.
Observat.
99.

AND (farther) to shew you, that the engine we are speaking of, is alterable, as well for the better as for the worse, by such motions of outward bodies, as, in themselves considered, are languid, or at least may seem despicable in reference to sickness or recovery; let me call upon you to consider a few, not unobvious, things, which may also serve to confirm some part of what has hitherto been delivered.

[THE true moss growing upon a human skull, though I do not find experience warrant all the strange things some chymical writers attribute to it for the stanching of blood, yet I deny not, but in some bodies it does it wonderful enough. And I very well know an eminent virtuoso, who has assured me, as his physician likewise has done, that he finds the effects of this moss so considerable upon himself, that after having been let blood, his arm falling to bleed again, and he apprehending the consequences of it, his physician who chanced to be present, put a little of the abovementioned moss into his hand; which, barely held there did, to the patient's wonder, stanch his blood, and gave him the curiosity to lay it out of his hand, to try, whether the moss were the cause of the blood's so oddly stopping its course; whereupon his arm, after a little while, beginning to bleed afresh, he took the moss again into his hand, and thereby presently stanch'd his bleeding the second time: and if I misremember not he added, that he repeated the experiment once more with the like success. The smoke of burnt feathers, or tobacco blown upon the face of an hysterical woman, does oftentimes almost as suddenly recover them out of fits of the mother, as the odour of perfumes did cast them thereinto.]

The effects
of the moss
growing on
a human
skull in
stanching
blood.

AND now I speak of cures performable by fumes, it brings into my mind, that a friend of yours and mine, and a person of great veracity, professes to have strangely cured dysenteries by a way usual enough; which is to make the patient sit over a chair or stool close on the sides, and perforated below, so that the anus and the

Burnt feathers, or the smoke of tobacco removes hysterical fits.

Cures of
dysenteries
by fumes.

neighbouring parts may be exposed to the fumes of ginger, which must be thrown upon a pan of embers, placed just under the patient, who is to continue in that posture, and to receive the fume, as long as he can endure it without too much fainting. And when I mentioned one of the cures, that was thus performed, to one, that is looked upon as a master of chymical arcana against diseases; he preferred before it (as he says upon experience) the shavings of hartshorn used after the same manner; and the remedy seems not irrational. But if in this distemper, the actual heat applied to the above-mentioned part of the body concur not to the effect, we may too, warrantably enough, add, that cures may be performed by far more minute corpuscles than those of smoke, insinuating themselves from without into the body. For I know a very dexterous goldsmith, who, when he overheats himself, as he often unawares does at hammering of plate, is subject to fall into gripings of the belly, which lead to fluxes; but his usual and ready cure is, as soon as conveniently he can, to heat his anvil, and sit upon it for a great while together, heating it hot again, if there be need. But to return to our medicinal smokes, it is known, that some find more good against the fits of the colick, by the clysters of the smoke of tobacco, than by any other physick they take; so that I know wealthy persons, that relying upon the benefit they find by this remedy, have left off sending for their physicians to ease them of the colick. And indeed, when I consider what an odd concrete even common foot is, and that many concretes, by being resolved into smoke, may be either more or otherwise unlocked, than they would be by the stomach of a man, (so that I may elsewhere entertain you of the great heightening of some emetick and cathartick simples in their operation, by their being reduced into smoke) and that also probably the operation of some fumes and odours may be much changed and improved by their not getting into the body by the mouth, but other parts, I am inclinable to think, that there might be made further use of them, if physicians pleased, than hitherto has been. For I have made such trial of the virtue of sulphureous smoke, to preserve some liquors, as I was much pleased with. And not only *Paracelsus*, but *Helmont* highly extols, as a grand specifick in fits of the mother, the smoke of the warts, that grew upon the legs of horses, conveyed to the parts supposed to be primarily affected. And I remember, that lately I met with a gentleman curious and intelligent, who, as himself assured me, was by the scurvy and ill-conditioned ulcers, and other obstinate distempers, brought so low, that he was scarce able to turn himself freely in his bed, and thereupon resolved against taking any more physick, partly out of despair of recovery, and partly of weariness of the tedious courses of physick the doctors had in vain made him pass through: but that some of his friends bringing him a certain surgeon, whom they affirmed to have strangely cured many desperate distempers, by ways very unusual and not troublesome to the patient, this gentleman was content to put himself into his hands; the surgeon promising, that he would not give him any other physick, but now and then a cup of sack by way of cordial; his way of cure being to fumigate the patient very well every morning with a certain smoke, which that gentleman thinks, by what he took notice of, in the powder that yielded it, to have been some vegetable substance. And with this remedy in a short time he grew perfectly well, and came home a while since in very good health, from a voyage, which the confusions of his own country invited him to make as far as the *East-Indies*. This surgeon, whose name I cannot hit upon, dying suddenly, his secret (which was tried upon divers others besides this gentleman) is, for aught we know, dead with him.

[But as for the efficacy, that may be found in appropriated fumes and steams, we have more than once, by barely unstopping and holding under her nose a small phial of

And by sitting on a hot anvil.

Cures of the colick by clysters of the smoke of tobacco.

Of other cures done by smokes.

of highly rectified spirit of sal-armoniack, or even of hartshorn, almost presently recovered a young beauty, I need not name to you, out of strange fits, that were wont to take her more suddenly than those of the falling-sickness, and were looked upon as epileptical, though perchance they were not merely so. To which I shall add, that a lady, that both you, *Pyrophilus*, and I know and love very well, though she have been long subject to violent and tedious fits of the head-ach, and though that distemper hath been much increased by a great concussion of her head, occasioned by the overturning of a coach, yet she is wont presently to be relieved, barely by holding her head a pretty while over a strong decoction of tea, and breathing in the steams of it.]

AND NOW I am discoursing of cures made by steams, or other seemingly slight means, I must not pretermit a thing so remarkable, that if it were more generally known in *Europe*, I shall think it somewhat strange to find it so little reflected on by physicians; and that is, the constant and almost sudden ceasing of the plague, how raging soever, in the almost incredibly populous city of *Grand Cairo* in *Egypt* towards the latter end of *June*, about which time in most countries in our hemisphere it is wont to spread fastest, and be most rife. The truth of this is attested by so many travellers of several nations, that it were injurious to doubt of it; and not only the dexterous Mr. *R.* whom you well know, and who lived at *Cairo*, has confirmed to me the truth of it, but the learned *Prosper Alpinus*, who both was an excellent physician, and spent many years in *Egypt*, gives us this particular account of it: *Pestis Cayri atque in omnibus locis Aegypti invadere eos populos solet ineunte Septembri mense, usque ad Junium: his enim omnibus mensibus, à Septembri ad Junium usque, pestis aliunde per contagium illuc asportata eam gentem invadere solet.* And after a few lines, *Junio verò mense, qualiscunque & quantacunque sit ibi pestilentia, sole primam cancri partem ingrediente, omnino tollitur, quod multis planè divinum esse non immeritò videtur: sed quo etiam valde mirabile creditur, omnia supellestilia pestifero contagio infecta tunc nullum contagii effectum in eam gentem edunt; ita ut tunc ea vobis in tutissimo & tranquillissimo statu reducatur ex summe morbofo: atque morbi particulares, sporadici à Græcis vocati, tunc apparere incipiunt, qui nusquam gentium tempore pestis apparebant.* ‘The plague at *Grand Cairo*, and in all parts of *Aegypt*, is wont to invade the inhabitants from the beginning of the month *September* until *June*: for in all these months, from *September* unto *June*, the plague from other nations is brought thither, and is wont to infect that nation. But in the month of *June*, of what nature and how great soever the pestilence be, when the sun first enters *Cancer*, it is immediately removed; which thing many (and that not without reason) take to be a particular mercy of God. But (what is more admirable) all household-stuff, however infected with the contagion of the disease, at that time shews no effect of any contagion, so that then the whole nation passes into a most secure and healthy condition, from a morbid and dangerous; and then those diseases, which are called by the Greeks *Sporadici*, begin to appear, which in no part of the world are seen to be rife together with the plague.’ And in the next chapter, inquiring at large into the causes of this wonder, he denies it to proceed from the increase of the *Nile*, which happens to be coincident in point of time with the extinction of the plague, because that the infection ceaseth before the swelling of the river is considerable; and ascribeth it rather to the alteration of the air, produced by the northerly winds, which then begin to blow, and some other circumstances: speaking of which, *Hæc* (saith he) *per id temporis incipiunt observari, à quibus fortasse non immeritò causam extinctionis pestis morbofique in salubrem statum mutationis pendere arbitror: quando nulla alia ex conservatricibus causis, quas vulgus medicorum res non naturales appellat, aëre excepto, ibi eo*

Of the sudden ceasing of the plague at *Grand Cairo* in *June*.

De medicina *Egyptiorum*. lib. i. cap. 17.

Ibidem, c. 18.

tempore appareat, in quam morboſi ſtatus in ſalubrem mutationem referre poſſumus: ideo neceſſarium erit huiusce mutationis cauſam aëris mutationi acceptam referre, &c. ‘Theſe things are firſt obſerved about that time. From which, I think, and perchance not without reaſon, the cauſe of the extinction of the plague, and the change of the ſtate from morbid to wholeſome doth depend; for no other of the conſervative cauſes, which are wont to be called by phyſicians *res nonnaturales*, appeareth then, beſides the air: to which we may refer this change from diſeaſe to healthineſs; and therefore we muſt refer this change to the change of the air.’ Upon this inſtance, *Pyrophilus*, I have preſumed the longer to inſiſt, becauſe (if you duly reflect on it) you will, I ſuppoſe, diſcern, that it much credits and elucidates a great part of what hath been delivered in divers of the foregoing leaves, concerning the poſſibility of nature’s doing great matters againſt diſeaſes, without the help of groſs and ſenſible evacuations.

C H A P. XV.

That human body may be altered by ſuch motions, as act in a groſs and meerly mechanical manner, proved by divers inſtances.

Hiſtor. Nat. Med. lib. 2. cap. 5. p. 33.

Idem, cap. 11.

AND ſince we have repreſented a human body as an engine, we ſhall add, that it may be altered both for the better and for the worſe, by ſuch bare motions or impulſes of external bodies, as act but in a groſs and confeſſedly mechanical manner. For it is known, that out of ſuch ſpeedily killing (unleſs ſeaſonably remedied) diſtempers, as fits of ſwooning, patients of either ſex are often recovered without any inward medicine, by being barely pinched in ſeveral places. I, that have endured great and dangerous ſickneſſes, have ſcarce ever found any ſo violent for the time, as that, which the bare motion and ſmell of a ſhip and ſea-air hath put me into, eſpecially in rough weather, till I was ſomewhat accuſtomed to navigation; and yet this violent and weakning ſickneſs, as it was not produced by a peccant humour in the body, ſo it was quickly removed by the air, and quiet of the ſhore, without the help of phyſick. And the like may be obſerved more ſuddenly in the newly mentioned inſtances of thoſe, in whom the bare agitation of a coach will produce ſuch violent fits of vomiting, and ſuch faintneſs, that I have known ſome of them apprehend they ſhould preſently die; ſo the bare ceſſation of that diſcompoſing motion ſoon relieved them. We ſee in our ſtables, what operation the currying of them carefully hath upon our horſes. And *Helmont* ſomewhere tells us, that himſelf, as I remember, could, by the milk of an aſs, tell whether ſhe had been that day diligently curried or no; and ſo conſiderable an alteration in milk ſhould methinks ſtrongly argue, that a great one is in the blood or other juice, of which the blood is elaborated, and conſequently in divers of the principal parts of the body muſt have preceded it. But to prefer our conſideration from the bodies of beaſts to thoſe of men, it is remarkable what *Piſo* confeſſeth, the illiterate Braſilian empiricks are able to perform with frictions, even as unſkilfully as they order them: *Mira equidem*, ſaith he, *tum tuendæ ſanitatæ ergo, cum in plerisque morbis ſanandis, frictione & unctiõne frequenti incolæ præſtant, illam frigidioribus, & chronicis, hanc in acutioribus adhibentes. Quæ remedia lubenter advenæ imitantur, & ut par eſt, ex legibus artis hæc & plura medendi empiricorum genera moderantur.* ‘The inhabitants do ſtrange things, both in preſerving health and in curing diſeaſes, by friction and unction, uſing the firſt in cold and chronic, the latter in acute diſeaſes. And ſtrangers, who arrive there, are, as they ought, willing to imitate their ways of phyſick, and by rules of art to preſide and moderate theſe ways of empirical healing.’ And as *Galen* himſelf highly extols a ſkilful application of cupping-glaſſes in the colick; ſo in *Braſil* they find, that the like remedy is ſtrangely ſucceſſful: for *Cholera ſicca*, ſaith our candid *Piſo* in another place, *eiſdem ſerè remediis* (of which he had been ſpeaking) *curatur, maxime ſi regioni*

regioni hepatis corneæ cucurbitulæ applicentur. De quibus merito hoc testor, quod Galenus de suis cucurbitulis, quas in colico affectu incantamenti instar operari tradidit. ' Cholera sicca is cured by the same remedies, especially if their horny cupping-glass be applied to the region of the liver, of which I must attest the same thing, that Galen doth of cupping-glasses; which he affirmed to work as miraculously, as if their operation had depended on enchantment.'

WE shall add, for further confirmation, that notwithstanding all the horrid symptoms, that are wont to ensue upon the biting of that poisonous spider, the *Tarantula*, that lasting and formidable disease, which often mocks all other remedies, is by nothing so successfully opposed, as by musick; some determinate tune or other, which proves suitable to the particular nature of the patient's body, or that of the poison, producing there such a motion, or determination of some former motion of the spirits, or the humours, or both, as by conducting the spirits into the nerves and muscles inservient to the motion of the limbs, doth make the patient leap and dance, till he have put himself into a sweat, that breathes out much of the virulent matter, which hath been probably fitted for expulsion, by some change wrought in its texture or motion, or those of the blood, by the musick. For if sweat and exercise, as such, were all that relieved him, why might not sudoricks, or leaping without musick, excuse the need of fidlers? which yet is so great, that *Kircher* informs us, that the Apuleian magistrates are wont to give stipends, at their publick charge, to such, to relieve the poor by their playing. And not only he hath the memorable story of *Robertus Pantarus*, a Tarantine nobleman, whose disease being not known to proceed from the biting of a spider, could by no remedies be cured; he was at length, even upon the point of death, suddenly relieved, and by degrees restored to perfect health by the use of musick: but *Epiphanius Ferdinandus*, in his accurate observations concerning those bitten with the tarantula, together with *Matthiolus*, and other authors, bear witness thereunto by resembling narratives. Now that a sound (not barely as a sound, but so modified) may powerfully operate upon the blood and spirits, I, who am very musically given, have divers times observed in myself, upon the hearing of certain notes. And it might be made probable, both by that, which we have formerly said of the effect of skreaking upon the teeth and gums, and by the dancing fit, into which not every musical sound, though never so loud, but some determinate tune is wont to put the bitten patient. But it may be more manifestly proved, by the following testimony of our inquisitive Jesuit, wherein he affirms, that the spiders may, as well as those they have bitten, be made to dance by tunes suited to their peculiar constitutions.*

AND this I the less wonder at, because *Epiphanius Ferdinandus* himself not only tells us of a man of 94 years of age, and so weak, that he could not go, unless supported by his staff, who did, upon the hearing of musick after he was bitten, immediately

The instances of the cure of the Tarantula by musick particularly modified.

Musurg. lib. 9. cap. 4.

* *Ubi sonatores, qui musica sua hoc malum etiam publicis magistratus stipendiis ad pauperum remedium solatiumque conducti curare consueverunt, ad curas patientium certius faciliusque accelerandus; primo ex infestis quærere solent ubi, quo loco, aut campo, aut cujus coloris Tarantula erat, a quo morsus ipsis fit infestus. Quo facta indicatum locum protinus, ubi frequentes numero atque omnis generis Tarantulæ retium texendorum laboribus incumbunt, accedere solent medici citrædi, variaque tentare harmoniarum genera: ad quæ (mirum dictu) nunc has nunc illas saltare non secus ac duorum polychordorum æqualiter concinnatorum, personatione illæ chordæ, quæ similes sibi fuerint tono, & æqualiter tensæ morventur, reliquis immotis, ita ut pro similitudine & conditione Tarantularum, nunc has nunc illas saltare comperiunt. Cum verò ejus coloris Tarantulam, quæ à patiente indicata fuerit, in saltum prorumpere viderint, pro certissimo signo habent, modulum se habere verum & certum, humori veneno is tagaverticos proportionatum, & ad curandum aptissimum, quo si utantur, infallibilem curæ effectum se consequi assueverunt. Kircher. Musurg. lib. 9. part 2. cap. 4.*

fall a dancing and capering like a kid; and affirms, that Tarantulas themselves may be brought to leap and dance at the sound of lutes, small drums, bag-pipes, fiddles, &c. but challenges those, that believe them not, to come and try, promising them an ocular conviction: and adds, what is very memorable and pleasant, that not only men, in whom much may be ascribed to fancy, but other animals being bitten, may likewise, by musick, be reduced to leap or dance: for he saith, he saw a wasp, which being bitten by a Tarantula whilst a lutanist chanced to be by; the musician playing on his instrument, gave them the sport of seeing both the wasp and spider begin to dance: annexing, that a bitten cock did the like.

C H A P. XVI.

Divers instances of the *Idiosyncrasia*, or peculiar aversion of particular persons from particular things, and of the commotions made in the body thereby.

I MIGHT also, *Pyrophilus*, confirm what I told you, when I said, that sickness may produce such an alteration in the fabrick of the body, as to make it capable to be very much affected, as well for the better as for the worse, by such things, that would not scarce at all effect it if it were sound, from the consideration of those many and strange *ιδιοσυγκρασίαι*, or peculiarities, to be met with in some persons in sickness and in health. For though many of these differences between healthy men are not likely to be greater, than may be observed between the same man, when well, and himself as the œconomy of his body may be discomposed by some distemper; yet we often see, that some persons have the engine of their body so framed, that it is wonderfully disordered by such things, as either work not at all on others, or work otherwise on them; as it is common enough for men to be hugely disturbed, and some of them to fall into fits of trembling and swooning, upon the sight or hearing of a cat. And to such an affection I knew a very eminent commander obnoxious, your late uncle, the last Earl of *Barrymore*, a very gallant nobleman, and who did his country great service in the Irish wars, had the like apprehension for tansey. I cannot see a spider near me, without feeling a notable commotion in my blood, though I never received harm from that sort of creature, and have no such abhorring against vipers, toads, or other venomous animals. You know an excellent lady (married to a great person, that hath more than once governed *Ireland*) whose antipathy to honey, which is much talked of in that country, hath displayed it self upon several occasions; notwithstanding which, her experienced physician imagining, that there might be something of deceit in her aversion, took an opportunity to satisfy himself, by mixing a little honey with other ingredients of a remedy which he applied to a very slight and inconsiderable cut or scratch, which she chanced to get on her foot; but he soon repented of his curiosity, upon the strange and unexpected disorder, which ceasing upon the removal of that, and application of other ordinary remedies, satisfied him, that those symptoms were to be imputed to the honey, and not the bare hurt. The same excellent lady, I remember, complained to me, that when she was troubled with coughs, all the vulgar pectoral and pulmonick remedies did her no good, so that she could find relief in nothing but either the fume of powdred amber, taken with convenient herbs in a pipe, or that *Balsamum sulphuris*, which we have already taught you in this essay.

[I KNOW a person of quality, tall and strong made, who lately asked my opinion, whether, when he had need of a vomit, he should continue to make use of coffee, in regard it wrought so violently with him: this gave me the occasion, as well as curiosity, of inquiring particularly both of himself and his lady, concerning this odd operation of coffee upon him; and I was told, that an ordinary wine-glass full of the usual warm decoction of coffee boiled in common water, was wont, within about two hours, to prove emetick with him, and before noon did give him eight, ten, or sometimes

times twelve vomits, with so much violence, that he was less affected by the infusion of *Crocus metallorum*, or other usual emeticks, and therefore was deliberating, whether he should not change coffee for some of them, though finding its operation very certain, he had for some years accustomed himself to take that vomit. And that, which is also remarkable in this matter, is, that he tells me, that scarce any vomit is more troublesome to him to take, than that above mentioned is grown of late, so that even the odour of coffee, as he passeth by the coffee-houses in the street, doth make him sick; and yet that simple is to most men so far from being vomitive, that it is by eminent physicians, and in some cases not without cause, much extolled as a strengthener of the stomach. And this very gentleman himself used it a pretty while against the fumes, that offended his head, without finding any vomitive quality at all in it.]

THE books of sober and learned physicians afford us examples of divers such, and of much more strange peculiarities, and likewise of such persons, who having desires of certain things very extravagant, and even absurd, (ordinarily not only improper, but hurtful to their distempers) have been cured by the use of them, of very dangerous and sometimes hopeless diseases: of which kind of cures I may also elsewhere tell you what I have observed, and some credit may be brought to such relations, by what we ordinarily see more greedily devoured (without much harm) by longing women, and maids troubled with the green-sickness.

BUT now, *Pyrophilus*, since the engine of an human body thus appears to be so framed, that it is capable of receiving great alterations from such unlikely things as those we have been mentioning; why should we hastily conclude against the efficacy of specifics, taken into the body, upon the bare account of their not operating by any obvious quality, if they be recommended unto us upon their own experience by sober and faithful persons? and that scarce sensible quantities of matter, having once obtained access to the mass of blood (which is very easily done by the circulation) may, by the contrary and swift motion, and by the figure of the corpuscles it consists of, give such a new and unnatural impediment or determination to the motion of the blood, as to discompose either its texture, or that of the heart, brain, liver, spleen, or some such principal part of the body, (as a spark of fire reduceth a whole barrel of gunpowder, to obey the laws of its motion, and become fire too; or as a little leaven is able, by degrees, to turn the greatest lump of dough into leaven) need be manifested by nothing, but the operations of such poisons, as work not by any of those (which physicians are pleased to call) *Manifest Qualities*. For though I much fear, that most of those, that have written concerning poisons, supposing that men would rather believe than try what they relate, have allowed themselves to deliver many things more strange than true; yet the known effects of a very small quantity of opium, or of arsenick, of the scarce discernable hurt made by a viper's tooth, and especially of the biting of a mad dog, (which sometimes, by less of his spittle than would weigh half a grain, subdues a whole great ox into the like madness, and produceth truly-wonderful symptoms both in mens bodies and beasts) are sufficient to evince what we proposed.

AND that man's body may be as well sometimes cured, as we see it too often discomposed, by such little proportions of matter, may (not now to mention the questionable virtues ascribed to many antidotes) be gathered from that experiment, so common in *Italy* and elsewhere, of curing the invenomed biting of scorpions, by anointing the bitten and tumid place with common oil, wherein store of scorpions have been drowned and steeped. And a resembling example of the antidotal virtue, wherewith nature hath enriched some bodies, is given us by the above commended

That since the body receives such alterations from such unlikely things, there is no just arguing against specifics, because they operate not by any obvious qualities.

Piso,

Piso, in his *Medicina Brasiliensis*, where (treating of the antidotal efficacy of the famous Brazilian herb *Nhanby*, eaten upon an empty stomach) he adds this memorable story; That he himself saw a Brazilian, who having caught an over-grown toad, and swelled with poison (such a one as Brazilians call *Cururu*) which used to be as big again as the European toad, and desperately venomous (which perhaps our toads are not) he presently killed him, by dropping on his back the juice of the flowers and leaves of that admirable plant. And you may remember, that the same author formerly told us, in effect, that as great and salutary changes may be produced even in human bodies, where he relates, that he had known those, that had eaten several sorts of poison, snatched in a trice from imminent death, by only drinking some of the infusion of the root he calls *Jaborandi*; and this, after I know not how many alexipharmaca and theriacal antidotes had been fruitlessly administered.

You will perchance tell me, *Pyrophilus*, that these three or four last instances are of poisonous distempers, and their antidotes; not of ordinary diseases, and their specifick remedies. But to this I have a double answer: and first, many of those distempers, that proceed from poison, are really diseases, and both called by that name, and treated of as such, by physicians. And indeed they may well look upon them but as diseases, exasperated by a virulent malignity, which yet appears to be not always easily distinguishable from that of diseases, that proceed not from poison, by this, that otherwise the physicians of princes and great men, if, after having considered all the inward parts of their dis-bowelled patients, could not so often doubt and dispute, as they do, whether or no poison were necessary to their death. And *Piso* (who learnt divers of their detestable secrets from the Brazilians) relates, That some of them are so skilful in the cursed art of tempering and allaying their poisons, that they will often hinder them from disclosing their deleterial nature for so long a time, that the subtle murderers do, as unsuspectedly as fatally, execute their malice or revenge. These diseases indeed are wont to differ in this from surfeits, and other resembling ordinary diseases; that in the one, the venomous matter, that produceth the disease, is at first much more small, than in the other the morbidick matter is wont to be. But the activity of this little quantity of hostile matter doth make it pernicious; that the disorders it produceth in the body, being much greater than that of ordinary sicknesses is, the cure of such distempers is the fitter to manifest how powerfully nature may be succoured by remedies, that work not by first or second qualities, since such are able to deliver her from diseases heightened by a peculiar and venomous malignity.

To this first I shall subjoin my next, which is, That divers passages of the former discourse (especially what we have related concerning the cures of agues, of the rickets, and of the king's evil) may satisfy you, that even of ordinary diseases (some at least) may be as well cured by specificks, as those produced by poison are by antidotes.

You may also say, *Pyrophilus*, 'But what if a recommended specifick do not only seem unable to produce the promised effect, but have qualities, which according to our notions of the nature of the disease, seem likely to conspire with it and increase it?'

I answer,

What is to be done, when the specifick seems likely to increase the disease.

FIRST, That though it is better for the patient to be cured by a rashly and unskilfully given medicine, than to die under the use of the most skilfully administered physick; yet that the physician, who loseth his patient, after having done all, that his art prescribed to save him, deserves more commendation than he, that luckily chanceth to cure his patient by an irrational course. And therefore in such a case

as you put, *Pyrophilus*, I think the physician ought to be very well satisfied, as to the matter of fact, before he venture to try such a remedy; especially if more ordinary and unsuspected means have not been employed and found ineffectual: for it is not one lucky cure, that ought to recommend to a wary physician the use of a remedy, whose dangerous quality seems obvious, where its virtue must be credited upon report.

BUT then, secondly, If the physician be duly satisfied of the efficacy of the remedy, upon a competent number and variety of patients, I suppose he may, without rashness, make use of such remedies, at least where ordinary medicines have been already fruitlessly tried.

C H A P. XVIII.

THAT you may cease to wonder at my daring to say this, *Pyrophilus*, I must offer to you three or four particulars.

AND first, it is manifest to those that are inquisitive, that the true nature and causes of several diseases are much less certain, and much more disputed of amongst the doctors themselves, than those that are not inquisitive imagine: nor is the method of curing divers particular diseases more settled and agreed on, that depending chiefly upon the knowledge of those causes, which, as I was saying, are controverted. It is not, that I am either an enemy to method in physick, or an undervaluer of it; but I fear the generality of physicians (for I intend not, nor need all along this essay speak of them all) have as yet but an imperfect method, and have by the narrow principles they were taught in the schools, been persuaded to change their method rather to the barren principles of the Peripatetick school, than to the full amplitude of nature. Nor do I find, that physicians have yet done so fit a thing, as seriously (and with the attention, which the importance of the thing deserves) on the one side, to enumerate and distinguish the several causes, that may any whit probably be assigned, how the phænomena of that disordered state of the human body, which we call a disease, or its symptoms, may be produced; and on the other side, by how many and how differing ways the phænomena may be removed, or the diseases they belong to destroyed: and if this were analytically and carefully done, I little doubt, but that men's knowledge of the nature and causes of diseases, and the ways of curing them, would be less circumscribed, and more effectual than now it is wont to be. And I am apt to think, that even methodists would then find, that there are divers probable, if not promising methods (proper to divers cases) which ways they yet overlook. And though in a right sense it be true, that the physician is but nature's minister, and is to comply with her, who aims always at the best; yet if we take them in the sense those expressions are vulgarly used in, I may elsewhere acquaint you with my exceptions at them, and in the mean time confess to you, that I know not whether they have not done harm, and hindered the advancement of physick, fascinating the minds of men, and keeping them from those effectual courses, whereby they may potentially alter the engine of the body; and by rectifying the motion and texture of its parts, both consistent and fluid, may bring nature to their bent, and accustom her to such convenient courses of the blood and other juices, and such fit times and ways of evacuating (what is noxious or superfluous, &c.) as may prevent or cure divers stubborn diseases, more happily than the vulgar methodists are wont to do.

AND indeed, it is scarce to be expected, that till men have a better knowledge of the principles of natural philosophy, without which it is hard to arrive at a more comprehensive theory of the various possible causes or diseases, and of the contrivance and uses of the parts of the body, the method which supposes this knowledge should

A disquisition concerning the ordinary method of physick.

be other than in many things defective, and in some erroneous; as I am apt to think, the vulgar method may be shewn to be, as to some particular diseases. Of this I may perhaps elsewhere acquaint you more particularly with my suspicions, and therefore I shall now only mention the last observation of this kind I met with, which was a gentleman, you and I very well know, who being for some months much troubled with a difficulty of breathing, and having been unsuccessfully treated for it by very eminent physicians, we at last suspected, that it was not the lungs, but the nerves, that served to move the diaphragm and other organs of respiration, upon whose distemper this supposed asthma depended: and accordingly, by a taking or two of a volatile salt of ours, which is very friendly to the *Genus nervosum*, he was quickly freed from his troublesome distemper, which afterwards he was fully persuaded did not proceed from any stuffing up of the lungs. To be short, how much esteem soever we have for method, yet since that it self and the theories whereon men ground it, are, as to divers particular diseases, so hotly disputed of, even among eminent physicians, that in many cases a man may discern more probability of the success of the remedy, than of the truth of the received notion of the disease; in such abstruse cases methinks it were not amiss to reflect upon that reasoning of the ancient empiricks (though on a somewhat differing occasion) which is thus somewhere expressed by *Celsus*: *Neque se dicere consilio medicum non egere, & irrationabile animal hanc artem posse præstare, sed has latentium rerum conjecturas ad rem non pertinere; quia non interfit, quid morbum faciat, sed quid tollat.* ‘Nor doth he say, that a physician needs nothing of counsel or deliberation, or that an irrational man may profess this art; but that those conjectures of hidden things are nothing to the purpose. Because it matters not what causeth the disease, but what removes it.’ And as the controverted method in the above-mentioned diseases is not yet established or agreed on in the schools themselves, so divers of those, that are wholly strangers to those schools, do yet, by the help of experience and good specifics, and the method their mother-wit does, according to emergencies, prompt them to take, perform such considerable cures, that *Piso* sticks not to give this testimony to the utterly unlearned Brazilian empiricks: *Interim, says he, seniores & exercitatiores eximii sunt botanici, facillique negotio omnis generis medicamina ex undiquaque in sylvis conquistis conficiunt. Quæ tanta sagacitate internè & externè illos adhibere videas, præcipuè in morbis è veneno natis, ut quis illorum manibus tutius & securius se tradat, quam medicastrois nostris sciolis, qui secreta quædam in umbra nata atque educata crepant perpetuò, & ob has rationales dici volunt.* ‘In the mean time, the Brazilian botanists make all sorts of medicines of simples they find every where in the woods: which they make with so great sagacity, and apply them both internally and externally, especially to diseases that spring from venom, that a man may more securely give himself over to their hands, than to our unskilful physicians, who brag much of secrets they have learnt in private, and for the knowledge of these will be called rationals in physick.’

SECONDLY, There are divers medicines, which, though they want not some one quality or other, proper to increase the disease, against which they are administered, are yet confidently used by the most judicious doctors, because that they are so enriched with other qualities, whereby they may do much more good than their noxious qualities can do harm: as in a malignant fever, though the distemper be hot, and though treacle and some other antidotal sudorifics be hot also, yet they are usefully administered in such diseases, because the relief they bring the patient, by oppugning the malignity of the peccant matter, and perhaps by easing him of some of it by sweat, is more considerable than the harm they can do him, by increasing for a while his heat.

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Instances
of some
medicines
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THE

THE very experienced *Bontius*, chief physician to the *Dutch* plantation in the *East-Indies*, in his *Methodus medendi Indica*, treating of the spasms, which (though here unfrequent) he reckons among the endemical diseases of the *Indies*, commends the use of *Quercetanus's* laudanum, of philonium, and principally of an extract of opium and saffron, which he describes and much extols: and lest his readers should scruple at so strange a prescription, he adds this memorable passage to our present purpose: *Fortassis* (says he) *sciulus quispiam negabit his remediis, propter vim stupefactivam ac narcoticam nervisque inimicam, esse utendum. Speciosa quidem hæc prima fronte videntur, sed tamen vana sunt. Nam præterquam quod calidissima hujus climatis temperies requirat, certissimum est in tali necessitate, sine his ægrum evadere non posse. Adde, quod nos tam ritè opim hic præparamus, ut vel infanti innoxie detur: Et sanè (ut verbo absolvam) si opiata hic nobis deessent in morbis calidis his grassantibus frustra remedia adhiberemus, quod etsi imperitis durum, ex progressu tamen me nil temere dixisse patebit.* ‘Perchance some sciolist in physick may affirm, that these things may not be used, by reason of the narcotick and stupefactive property. But these pretences are as vain in effect as specious at first sight: for besides that the hot temper of this country requires it, it is sure, that without these remedies there can be no cure. Add, that here we prepare opium so well, that you may give it to an infant. And truly, if in hot diseases we had no opiates, we should in effect find, that the use of all other medicaments would prove altogether vain and fruitless.’

THE drinking freely, especially if the drink be cold water, is usually (and in most cases, not without much reason) strictly forbidden, as very hurtful for the dropsy; and yet those, that frequent the *Spaw*, tell us of great cures performed by pouring in plenty of waters into the patient's already distended belly. And I know a person of great quality and virtue, who being by an obstinate dropsy, besides a complication of other formidable diseases, brought to a desperate condition, was advised to drink *Tunbridge-waters*, when I happened to be there, by her very skilful physician; who told me, that the doctors having done all their art could direct them unto, in vain, she would be cured by death, if she were not by these waters; from whence (the weather proving very seasonable for that sort of physick) she returned in so prosperous a condition of recovery, as exacted both his and my wonder. That the decoction of so heating a simple as guaiacum would be looked upon by the generality of physicians, both Galenists and Chymists, as a dangerous medicine in phthisical and other consumptions, you will easily grant: and yet some eminent physicians, and (particularly Spaniards) tell us of wonderful cures they have performed in desperate ulcers of the lungs, by the long use of this decoction, notwithstanding its manifestly and troublesomely heating quality. And I know a physician eminently learned, and much more a methodist than a chymist, who assures me, that he has made trial of this unlikely way of curing consumptions with a success, that has much recommended these paradoxical Spaniards to him. It is also believed, and not without cause, by physicians, that mercury is wont to prove a great enemy to the *genus nervosum*, and often produces palseys, and other distempers of the brain in the nerves: and yet one of the exactest and happiest methodists I know, has confessed to me, that mercurial preparations are those, which he uses the most successfully in paralytical and the like distempers of, what physicians call, the *genus nervosum*. And on this occasion I remember, that a gentlewoman being confined to her bed by a dead-palsey, that had seized on one side of her body, a physician eminent for his books and cures, giving her a dose of a certain preparation of mercury, corrected with a little gold, which I put into his hands for that purpose, was pleased to bring me word, that by the first taking of the powder, which wrought but gently by siege, without either vomits

Of the use of guaiacum for consumptions, and mercury for palseys.

or salivation, she was enabled the same or the next day to quit her bed, and walk about the room.

THIRDLY, there are many things, which seem to be against reason, whilst they are barely proposed and not proved, for which we afterwards discern very good reason; when experience having satisfied us they are really true, has both invited us, and assisted us, to inquire into their causes. Of this we have elsewhere given divers not medical instances in our essay *concerning improbable truths*: and I could easily enough, if I durst be tedious, give you some medical illustrations of the same truth. But I dare now only to invite you to consider this one thing, which may be of great use to explicate many others, both in natural philosophy, and in physick too; which is, that there are divers concretes, some of them, as to sense, similar, or homogeneous, whose differing parts are endowed with very differing and sometimes contrary qualities. And this not only appears in the chymical analysis of bodies made by the fire, where the difference of what chymists call the separated principles of concretes, is often very manifest and great, but even in divers bodies, that have not been resolved by the violence of the fire; as is evident in rhubarb taken in substance, whose subtiler parts are purging, and its terrestrial astringent. Nay, if those parts, which do in much the less quantity concur to the constitution of the concrete, do but meet with a body disposed to receive their impressions, it is very possible, that they may work more powerfully on it than the other parts of the same concrete, of which the eye judgeth it altogether to consist.

That there are divers concretes as to sense, similar, whose different parts have contrary qualities; as rhubarb and oil-olive.

THIS I have made out to some ingenious men, by shewing, that though tallad-oil be generally reputed to consist of fat and unctuous particles, and therefore to be a great resister of corrosion; yet it contains in it sharp and piercing parts, which meeting with a disposed subject, do more powerfully operate, than the purely oleaginous ones. As we endeavoured to evince, by keeping for a short while, in a gentle warmth, some pure oil-olive, upon a quantity of filings of even crude copper: for from them the liquor extracted an high tincture betwixt green and blue, like that, which such filings would have given to distilled vinegar, which, according to chymists notions, obtains that colour, by making with its acid and corrosive salt a real solution of some part of the copper, as may appear by the recoverableness of the metal out of it. Another proof or two of the acrimony of some of the parts of oil, we may elsewhere give you. But now we shall rather confirm our answer to your question, by two or three examples of cures performed by unlikely remedies.

Of improbable cures, viz. of a laudanum opiatum.

I WENT once to visit an ingenious Helmontian, whom I found sick on his bed; and having by the symptoms of his disease discerned it to be a pleurisy, I talked with him of seasonably opening a vein, but he was resolved against it; and told me he would cure himself by a remedy, which at first seems as likely to increase such a disease as phlebotomy is to cure it; namely, by the use of *Helmont's laudanum opiatum*, which in effect did in three or four days cure him, and since, he, without blood-letting, cured some others with it: which I the less wonder at, because of my having observed, that opium (with which unskilful men seldom tamper without danger) if duly corrected and prepared, proves sometimes a great resolver, and commonly a great sudorifick; insomuch, that I have known it make a person copiously sweat, who often complained to me, that other diaphoreticks had no such operation on him.

I HAVE oftentimes seen coughs strangely abated by the use of a remedy, which I have not long since told you how I prepare; and with which (I remember) in a pretty child you, *Pyrophilus*, know, and who is now very well, I was so happy as to repress

represents in a few hours a violent cough, that threatned her with speedy death; and yet this medicine has so eminent a saltness, that the tongue can scarce suffer it: and how much the use of salt things, is by many physicians condemned in coughs, (and indeed in many cases not without reason) I need not tell you. And with exceedingly piercing essence or spirit of man's blood, I have known, notwithstanding its being very saline, and its manifestly heating the patient, especially for the first four or five days, strange things performed, even in a deplorable and hereditary consumption. This, *Pyrophilus*, brings into my mind something, that, it may be, you will think odd: which is, that having had occasion to advise, for a person of high quality, with a very ancient Galenist, that in his own country was looked upon as almost an oracle, and particularly in reference to phthisical consumptions, which was there a vulgar disease; he confessed to me, that although his having fallen into it himself, made him very solicitous to find a cure for it; and though he had, in his long and various practice, made trial of great variety of methods and remedies for the cure of that disease, yet that, with which he cured himself, and afterwards the generality of his chief patients, was principally sulphur melted and mingled in a certain proportion to make it fit to be taken, in a pipe, with beaten amber or a cephalick herb. The particular circumstances of his method I cannot now set you down, not having by me the paper, wherein they were noted; but, if I mistake not, the herb, with which he mingled the brimstone of flour of sulphur, was colts-foot or betony; and I well remember, that what he looked upon as the chief and specifick remedy in his way of curing, was the smoke of the sulphur; the other ingredients being added, not so much for their being proper enough for the disease, as their helping to fill the pipe; and thereby to allay the pungency, wherewith the smoke, if afforded by a pipe filled with brimstone alone, would be qualified. But yet this sulphureous smoke is so predominant in the remedy, that he used to have a syrup in readiness to relieve those, whom the acrimony of the fumes should make very sore, and perhaps blister on the one side of their mouths, or throats; which accident he provided for, by that cooling and healing syrup, without being thereby discouraged from prosecuting the cure with the same remedy; wherewith a person, very curious and rich, has solemnly assured me, that himself has cured divers consumptions, and particularly in a lady, even in health very lean, that he named to me, as being one I then knew. Now we know, that physicians generally, and in most cases justly, forbid acid things to those, that have exulcerated or tender lungs; and how highly acid and piercing the smoke of sulphur is, the chymists can best tell you, who, by catching it, and condensing it in glasses shaped almost like bells, obtain from it that very corrosive liquor, which readily dissolves iron, being the very same, that is commonly called *Oleum sulphuris per campanam*: and yet it seems, that either the theory of consumptions is misunderstood, or that the drying quality of the sulphureous steam, and its great power to resist putrefaction, and as it were embalm the lungs and season the blood, are considerable enough to account for the harm, which its acidity may do.

EELS are so commonly eaten by persons of both sexes, without being taken notice of for any quality, except their crudity, that one would scarce believe such a stinking and odious medicine, as that of their livers and galls, dried slowly in an oven, should be more proper for any thing, than to make the taker vomit: and yet *Helmont* in divers places speaks of the medicine, as if it had kept multitudes of women from dying of hard labour. And since him, *Panarola* in his *New Observations* highly extols it. And I knew a very famous empirick, who had very few other secrets, and scarce any one so great to get reputation and money by. And I remember also, that some years since I had occasion to give it to the wife of a very ingenious physician,

Of curing coughs and consumptions by saline medicines.

Of the curing phthisical consumptions by the acid smoke of sulphur.

The use of the livers and galls of eels in expediting the hard labour of women.

of

of whom the midwives and her husband almost despaired, and (as she afterwards told me her self) each dose made her throws (which before had left her) return; and at length she was safely delivered, she scarce knew how. But I found double the dose prescribed by *Helmont* requisite to be used at last, and that the quantity of a walnut of the powder of these livers given in Rhenish or white-wine, and when the stomach was most empty, was no more than such a case required.

The unlike-
ly cure of
venom by
oil of scor-
pions.

SCORPIONS being venomous creatures, to suffocate and infuse them in oil, might seem the way to make it poisonous; if experience did not assure us, that this oil is so far from being such, that it cures the invenomed bitings of scorpions; which effect, now that the physicians find it upon trial to be true, they confess to be rational; and ascribe it, how justly I now examine not, to the attraction of the poison received into the body by that, which is outwardly applied to the hurt. And *Piso* informs us, that amongst the *Brasilians*, whose country is so much infested with venomous creatures, it is the most general cure to draw out the poison, by applying to the hurt the beaten body of the beast, that gave it. As likewise in *Italy*, they account the crushing of the very scorpion, that has bit a man, upon the bitten place, for a most speedy and effectual remedy. And I remember, that here in *England* the old man, whom you have seen going about with vipers, toads, &c. to sell, told me, that when he was dangerously bitten by a viper, and all swelled by the poison of it; a great part of his cure was the outward application of venomous creatures, stamped till they were brought to a consistence fit for that purpose.

And of
fluxes by
fresh butter
melted.

THAT fluxes are the general and endemical diseases in *Ireland*, I need not tell you; and yet I remember, that having occasion to consult the ancientest and most experienced physician of that nation, Dr. *F.* about the cure of it, he assured me, that though during his very long practice he had found divers remedies very prosperous, some on one sort of patients, and some on another; yet the medicine he most relied on, was this: To take unsalted butter, and boil it gently till a pretty part was consumed; skimming it diligently from time to time, whilst it stands over the fire; and of this butter melted, to give now and then a considerable quantity, according as the patient is able to bear it. A remedy, which, at the first proposal, may seem more likely to put a man into a flux, than to cure him of one. And yet the same remedy, which, he supposed to benefit by mitigating the sharp humours, and preserving the entrails from their corrosion, was afterwards much commended to me by another ancient *Irish* physician, who was esteemed among the doctors the next in eminency to him that I have named.

C H A P. XIX.

I SHOULD not here, *Pyrophilus*, add any thing to what I have already said above in favour of the use of even odd specifics, but, that finding at every turn, that the main thing, which does (really or in pretence) prevail with many learned physicians (especially in a famous university you have visited abroad) to reject specifics, is, that they cannot clearly conceive the distinct manner of the specifics working; and think it utterly improbable, that such a medicine, which must pass through digestions in the body, and be whirled about with the mass of blood to all the parts, should, neglecting the rest, shew it self friendly to the brain (for instance) or the kidneys, and fall upon this or that juice or humour rather than any other. But to this objection, which I have proposed as plausible as I can readily make it, I shall at present but briefly offer, according to what has been hitherto discoursed, these two things.

AND first, I would demand of these objectors a clear and satisfactory, or at least an intelligible explication of the manner of working of divers other medicaments, that do not pass for specifics; as how rhubarb purges choler, and hellebore melancholy rather than other humours; how some medicines, that have endured a strong fire, as *Antimonium diaphoreticum*, and *Bezoardicum minerale* well made, are yet oftentimes strongly sudorific; why the infusion of *Crocus metallorum* or of glass of antimony, though it acquire no pungent, or so much as manifest taste, whereby to vellicate the palate or the tongue, are yet violently both vomitive and cathartick; and how mercury, which is innoxiously given in many cases crude to women in labour and others, does easily acquire, besides many other more abstruse medicinal qualities, not only an emetick or purgative, but a salivating faculty. For I confess, that to me, even many of the vulgar operations of common drugs seem not to have been hitherto intelligibly explained by physicians, who are yet, for aught I have observed, to seek for an account of the manner, how diureticks, how sudorifics, how scaroticks, and how many other familiar sorts of medicines, which those, that consider them slightly, are wont to think they understand thoroughly, perform their operations. Nay, I much question, whether the generality of physicians can yet give us a satisfactory account, why any sort of medicine purges in general: and he, that in particular will shew me, where either the peripatetick, or Galenical schools, have intelligibly made out, why rhubarb does particularly purge choler, and senna more particularly phlegm, *erit mihi magnus Apollo*. For I see not how from those narrow and barren principles of the four elements, the four humours, the four first qualities (and the like) effects, far less abstruse than the operations of purging medicines, can satisfactorily be deduced. Nor can I find, that any thing makes those physicians, that are unacquainted with the philosophy, that explains things by the motions, sizes, and figures of little bodies, imagine they understand the account, upon which some medicines are purgative, others emetick, &c. and some purgative in some bodies, vomitive in other, and both purgative and vomitive in most; but because they never attentively inquire into it.

That it is very hard to give an intelligible explication of the operation of electives, and other common medicinal medicines, which are not specifics.

BUT (which is the next thing I have to represent) if we duly make use of those fertile and comprehensive principles of philosophy, the motions, shapes, magnitudes and texture of minute parts of matter; it will not perhaps be more difficult to shew, at least in general, that specifics may have such operations, as are by the judicious and experienced ascribed to them, than it will be for those, that acquiesce in the vulgar principles of philosophy and physick, to render the true reasons of the most obvious and familiar operations of medicines. And though the same objection, that is urged to prove, that a specifick cannot befriend the kidneys, for example, or the throat rather than any other parts of the body, lies against the noxiousness of poisons to this or that determinate part; yet experience manifests, that some poisons do respect some particular part of the body, without equally (if at all sensibly) offending the rest: and we see that cantharides in a certain dose are noxious to the kidneys and bladder, quicksilver to the throat, and the glandules thereabouts, stramonium to the brain, and opium to the animal spirits and genus nervosum. And if you call to mind, what we have formerly deduced to make it out, that a human body is an engine, and the medicines operate in it as finding it so; we need not think it so strange, that there being many strainers, if I may so call them, of differing textures, such as the liver, spleen, and kidneys, and perhaps divers local ferments residing in particular parts, and a mass of blood continually streaming through all the parts of the body, a medicine may be quickly, by the blood, carried from any one part to any other, and the blood, or any humour mingled with it, may be as easily carried to

That poisons do respect particular parts, and therefore medicines may do it.

the

General explanations of the manner, how these operations of specifics may proceed,

the medicine, in what parts soever it be; and the remedy thus admitted into the mass of blood may, in its passage through the strainers, be so altered, either by leaving some of its parts there, or by having them altered by the abovementioned ferments, or by being associated with some other corpuscles, it may meet with in its passage; whereby the size, or figure, or motion of its small parts may be changed; or, in a word, it may by some of those many other ways, which might, if this essay were not too prolix already, be proposed and deduced, receive so great an alteration, in reference either to some or other of the strainers, or other firmer parts of the body, or to the distempered blood, or some other fluid and peccant matter, that it needs not seem impossible, that by that time the medicine (crumbled as it were in minute corpuscles) arrives at the part or humour to be wrought upon, it may have a notable operation there. I mean *part* as well as *humour*, because the motion, size, or shape of the medicinal corpuscles in the blood, though not by sense distinguishable from the rest of the liquor they help to compose, may be so conveniently qualified, as to shape, bulk, and motion; as to restore the strainers to their right tone or texture, as well as the blood to its free and natural course; by resolving and carrying away with them such tenacious matter, as stuffed or choaked up the slender passages of the strainer, or at least straitened its pores, or vitiated their figure. And the same sanative corpuscles may perchance be also fitted to stick to, and thereby to strengthen such fibres of the strainers, or such other firmer parts of the body, as may need congruous corpuscles to fill up their little unsupplied cavities.

MEATS, that are salt, and tartareous, whilst they are whirled about in the mass of blood, may by the other parts of that vital liquor be so diluted and kept asunder so, as not to be offensive to any part: when they come to be separated by the parenchyma of the kidneys, from the sweeter parts of the blood, that did before temper and allay them, they easily, by their saline pungency, offend the tender ureters and membranous bladders of those, that are troubled with the stone or strangury. And perchance it is upon some such account, that cantharides are more noxious to the bladder than to other parts of the body. And as salt meat thus grows peculiarly offensive to the reins and bladder; so a specifick, disposed to be dissolved, after a peculiar manner, may, in the body, either preserve or acquire, as to its minute parts, a friendly congruity to the pores of the kidneys, liver, or other strainers equally, when distempered; as I formerly observed to you, that new-milk sweetened with sugar-candy, though it be not wont sensibly to affect any other part of the body, nor would have sensibly affected the kidneys themselves, had they not been disordered: yet after the troublesome operation of cantharides, it had a very friendly effect upon the distempered parts. Thus a specifick for one disease may be resolved in the body into minute particles of such figure and motion, that being fit to stick to other corpuscles of peccant matter, which, by their vehement agitation, or other offensive qualities discompose the body and make it feverish, may allay their vehement motion, and by altering them, as to bigness and shape, give them new and innocent qualities, instead of those noxious ones they had before.

ANOTHER specifick may dissolve the gross and slimy humours, that obstruct the narrow passages of the veins; as I have observed, that spirit of harts-horn, which powerfully opens other obstructions, and resolves stuffing phlegm in the lungs, will also, though more slowly, resolve prepared flowers of sulphur, crude copper, and divers other bodies; and also it may, by mortifying the acid spirit, that oftentimes causes coagulations in the blood, restore that vital liquor to its fluidity and free circulation, and thereby remove divers formidable diseases, which seem to proceed from the coagulation or ropiness of the blood; and, on the other side, the minute parts of

of some specificks against a contrary disease may somewhat thicken and fix the too thin and agitated parts of the blood, or of some peccant matter in it, by associating themselves therewith; as the nimble parts of pure spirit of wine, and those of high rectified spirit of urine, will concoagulate into corpuscles, bigger and far less agile. And the same spirit of wine it self, with another liquor I make, will presently concoagulate into a kind of soft, but not fluid substance. Nor is it so hard to conceive, that a specifick may work upon a determinate part or humour, and let the others alone: as if you put, for instance, an egg into strong vinegar, the liquor will operate upon and dissolve all the hard shell, and yet leave the tender skin untouched. And if you cast coral into the common rectified spirit of tartar, the far greater part of the liquor, though strong and spirituous, will remain unaltered thereby, and may be, *integris viribus*, abstracted from it; but the coral will presently find out, or rather be found out by acid or acetous particles, and by incorporating it self with them, take away their sharpness: as in some cases coral has been observed to do to four humours abounding in human bodies, those humours being easily, by the circulating blood, brought (in their passage) to the coral, whilst it perhaps remains in the stomach or guts. And though the circulation of the blood be sufficient to bring, little by little, the acid particles of that liquor in its passages through the vessels to work upon coral; yet in other medicines the operation may be more nimble, the remedy quickly diffusing it self through the mass of blood, to seek, as it were, and destroy the acid parts, which it meets with blended with the rest of the liquor. As spirit of urine being, instead of coral, put into the above mentioned spirit of tartar, will not (that I have observed) fasten it self to the spirituous nor the phlegmatick parts of the liquor, but only to the acid ones, which it will mortify or deprive of their founness by concoagulating with them. And I see not, why it should be more inconceivable, that a specifick should have a peculiar virtue to free the body from this or that peccant humour, and a benign congruity to the distempered spleen or liver, than that some cathartick should purge electively, and some antidotes have peculiar virtues against such poisons, whose malignity particularly invades the brain or kidneys, or some other determinate part: the former of which the physicians, we reason with, scruple not to teach; and the latter of which is taught us not by them only, but by experience too.

That vinegar will operate on the shell, and not upon the other parts of the egg; with like instances of specifick operations.

[OF the credibility of specificks, and of the efficacy even of some unlikely ones, we might easily enough present you with more proofs and examples: but these may possibly be sufficient for our present purpose; especially, if you duely consider, that as physick had owed its beginning to experience, so those, that practise it, must enlarge and rectify their principles according to the new discoveries, which are made from time to time of the operations and power of the productions whether of nature or of art. This consideration I thought to insist upon in my own expressions; but finding lately the same notion, which I had, to have been long since that of the ancient empiricks, I will sum up what I meant to say, in their words, as I find them wittily delivered by *Celsus*, in that excellent preface, where having spoken in their sense of the origin of physick, he continues, *Sic medicinam ortam, subinde aliorum salute, aliorum interitu perniciofa discernentem à salutaribus: repertis deinde medicinæ remediis, homines de rationibus eorum disserere cepisse; nec post rationem, medicinam, esse inventam, sed post inventam medicinam, rationem esse quesitam.* ‘Such was the origin of physick: by the recovery of some, and the death of others, it first made distinction between things sovereign to heal, and things which are improper and deadly. And thus the remedies being found out, men began to dispute of the reasons of them. Nor was the art of medicine found out by the light of reason; but, medicine being found, the reason began to be inquired into.’ And lest the mistaken name of empirick should make you undervalue so useful a con-

That physick, as it begun by experience, so it must be enlarged and rectified by the new discoveries of experience.

sideration, which not the nature of their sect, but that of the thing, suggested to them; I shall add, in favour of what we have delivered concerning experienced, though otherwise unlikely remedies, that it is a sentence ascribed to *Aristotle* (and, in my opinion, one of the best, that is ascribed to him) *Ubi res constat, si opinio adversetur rei, querendam rationem, non rem ignorandam.* 'Where the matter is certain, if it be against the common opinion, the reason must be sought, and not the matter of fact scrupled.'

AND certainly, *Pyrophilus*, though there be scarce any sort of men, whose credulity may do the world more mischief than that of physicians; yet perhaps, neither nature, nor mankind is much beholden to those, that too rigidly, or narrowly, circumscribe, or confine the operations of nature, and not so much as allow themselves or others to try, whether it be possible for nature, excited and managed by art, to perform divers things, which they never yet saw done, or work by divers ways, differing from any, which by the common principles, that are taught in the schools, they are able to give a satisfactory account of.

To the many things, which you may be pleased to apply to this purpose out of the precedent discourse, divers others may be added, if, without tiring you, they may be now insisted on. It would scarce have been believed some ages since, by those, that knew no other than vegetable purges and vomits, that a cup made of a concrete, insuperable by the heat of human stomachs, should, by having for a while, wine, or any such other liquor, barely poured on it, to make an infusion, without any sensible diminution of its own bulk or weight, and without any sensible alteration made in the colour, taste or smell of the wine, communicate to it a strongly emetick and cathartick virtue, and prove oftentimes vomitive, even when put up in the clysters; and yet that this is performable by antimony, slightly prepared with salt-petre, or without addition, melted into a transparent glass, is commonly known to those, that are not strangers to the operations of the antimonial cup, and of the glass made of the same mineral. And much more strange is that, which is affirmed by inquisitive physicians upon their own trial of the common *crocus metallorum*, or somewhat corrected antimony wont to be sold in shops; namely, that a few drachms of it, infused into some ounces of wine, will make the liquor work so strongly, as if six or eight times the quantity had been steeped in it.

That the operations of the antimonial cup, glass of antimony, and crocus metallorum, would not have been credited in ancient times.

THOSE that believe, that all diaphoreticks must consist of subtile, sapid, and fugitive parts, as if only such were easily separated from each other, and agitated by the gentle heat of a human body, will scarce expect, that any body could, in a moderate dose, be a good sudorifick, that is so fixt as to be able to persist divers hours in a good fire. And yet that *Antimonium diaphoreticum* is such a concrete, is now very well known to many besides chymists.

THAT a stone, and a stone too so fixed, that will sustain the violence of reverberated fire, and is consequently very unlikely to be much wrought upon, or digested by the heat of a human stomach, should be capable of agglutinating together the parts of broken bones, would seem impossible to many; but it is very well known to those, that have made trial of the efficacy of the *Lapis ossifragus*. For though I have sometimes wondered at the fixedness of this stone above others in the fire, yet being for some days successively drunk in wine, or aqua symphyti, to the quantity of about half a drachm, or more, it doth so wonderfully cement together the parts of broken and well-set bones, that it deserves the name it commonly hath in the shops of *Osteocolla*, and hath wonders related of it by several eminent, not only chymical, but Galenical writers.

Divers other instances alike incredible.

IT is almost incredible what *Quercetan* relates, of what himself saw done with it as to the cure of broken bones, without much pain, or any of the usual grievous

symptoms,

symptoms, within four or five days; so that to the stupendous virtue he ascribes to this stone, both inwardly given, and outwardly applied in the form of a pultis, with only beaten geranium and oil of roses or olives, he thinks fit to annex these words: *Quod incredibile videri posset, nisi præter me innumerabiles alii oculati & idonei testes extarent.* And indeed these need good proof to make a wary man believe so strange a thing, since surgeons observe, that nature is wont to be forty days in producing a callus to fasten together the pieces of a broken bone. But to make this the more credible by the testimony of authors more Galenically inclined, *Matthiolus* relates, that in many the bones having been very well set (which circumstance he requires as necessary) have had their broken parts conglutinated within three or four days. And not only that most experienced surgeon *Fabricius Hildanus* used it much in fractures, with only a little cinnamon and sugar to make it pleasant; but the learned *Sennertus*, who somewhere calls its virtue admirable, thinks it requisite, in his surgery, to give us this caution of it: *Verum in juvenibus, & iis qui boni sunt habitus, callum nimis auget; quapropter cautè & non nisi in adultioribus exhibendus.* The warrantableness of which caution, and consequently the strange efficacy of osteocolla, as, I remember, confirmed to me not long since by a skilful physician, who hath particularly studied its nature, and related to me, that some years since his mother, having by a fall broken her leg near the knee, had too suddenly, by the overmuch use of this stone, a callus produced in the part much bigger than he expected or desired.

He that, before the salivating property of mercury was discovered, should have told physicians of the despondent temper of these, we are now discoursing with, that besides the known ways of disburthening nature, (namely, by vomit, siege, urine, sweat, and insensible transpiration) there were a sort of remedies, that would make very large evacuations by spittle, and thereby cure divers stubborn diseases, that had been found refractory to all ordinary remedies, would certainly have been more likely to be derided than believed by them; since no known remedy, besides mercury, hath been, that I remember, observed to work regularly by salivation. For though cerufs of antimony have been observed to make men, of some constitutions, apt to spit much, yet it works that way too languidly, to deserve the name of a salivating remedy, and probably oweth the quality it hath of inclining to spit, to the mercurial part of the antimony, (wherewith the regulus, it is made of, abounds) and therefore the greater their experience of the effects of medicinal operations should be supposed to be, the greater indisposition it would give them to credit so unallied a truth. And yet the reality of the fluxing property of quicksilver is long since grown past question, and hath been found so useful in the cure of the most radicated and obstinate venereal distempers, that I somewhat wonder those physicians, that scruple not to employ as boisterous ways of cure, have not yet applied it to the extirpation of some other diseases; as ulcers of the kidneys, consumptions, and even palsies, &c. wherein I am apt to think it may be as effectual, as in those produced by lust, and much more effectual than vulgar remedies, provided that the exceeding troublesome way of working of salivating medicines be better corrected, than it is wont to be in the ordinary medicines employed to produce salivation, which they do with such tormenting symptoms, that they are scarcely supportable. But if purified quicksilver be dexterously precipitated by a long and competent digestion, with a due proportion of refined gold, experience hath informed us, that the salivating operation of it may be performed with much less uneasiness to the patient. And that such mercurial medicines, wherein the quicksilver is well corrected by gold, may produce more than ordinary effects, we have been inclined to believe, by the trials, which we procured by learned physicians to be

Fab.
Cent. 3.
Obfer. 90.
Lib. 5.
part 5.
Cap. 1.

made in other than venereal diseases, of a gently working precipitate of gold and mercury, of which we may elsewhere set you down the process.

[AND now I am upon the discourse of the peculiar operations of mercury, and of unusual ways of evacuation, I am tempted to subjoin an odd story, which may afford notable hints to a speculative man, as it was related to me both in private, and before illustrious witnesses, by the formerly commended chymist of the French king: he told me then a while since, that there is yet living a person of quality, by name *Monfieur de Vatteville*, well known by the command he hath or had of a regiment of *Switzers* in *France*, who, many years ago following the wars in the Low Countries, fell into a violent distemper of his eyes, which, in spite of what physicians and surgeons could do, did in a few months so increase, that he lost the use of both his eyes, and languished long in a confirmed blindness; which continued till he heard of a certain empirick at *Amsterdam*, commonly known by the name of *Adrian Glasmaker* (for indeed he was a glazier) who being cried up for prodigious cures he had done with a certain powder, this colonel resorted to him, and the empirick having discoursed with him, undertook his recovery, if he would undergo the torment of the cure: which the colonel having undertaken to do, the surgeon made him snuff up into each nostril about a grain of a certain mercurial powder, which in a strangely violent manner quickly wrought with him almost all imaginable ways, as by vomit, siege, sweat, urine, spitting, and tears, within ten or twelve hours that this operation lasted, making his head also to swell very much; but within three or four days after this single taking of the draffick medicine had done working, he began to recover some degree of sight, and within a fortnight attained to such a one, that he himself assured the relater, he never was so sharp-sighted before his blindness. And the relater assured me, that he had taken pleasure to observe, that this gentleman, who is his familiar acquaintance, would discern objects farther and clearer than most other men. He added, that *Monfieur de Vatteville* told the relater, he had purchased the way of making this powder of the empirick, and had given it to an eminent surgeon, one *Benoeft* (an acquaintance of the relater's) by whom he had been cured of a musket shot, that had broken his thigh-bone, when the other surgeons would have proceeded to amputation; and that this *Benoeft* had with this powder, administered as before is related, cured a gentlewoman of a cancer in the breast. All which, and more, was confirmed to the relater by the surgeon himself. But in what other stubborn and deplorable cases they use this powder, I do not particularly remember. The preparation of it, which a chymist did me the favour to tell me by word of mouth, as a thing himself had also made, was in short this: that the remedy was made by precipitating quicksilver with good oil of vitriol, and so making a turbith, which is afterwards to be dulcified by abstracting twenty or twenty five times from it pure spirit of wine, of which fresh must be taken at every abstraction. But I would not advise you to commend so furious a powder to any, that is not a very skilful chymist and physician too, till you know the exact preparation, and particular uses of it; the reason of my mentioning it here, being but that, which I expressed at the entrance upon this narrative.]

C H A P. XX.

YOU will perchance wonder, *Pyrophilus*, that having had so fair an opportunity as the subject of this essay afforded me, of discoursing to you about the universal medicine, which many Paracelsians, Helmontians, and other chymists talk of so confidently: I have said nothing concerning the existence, or so much as the possibility of

A strange
cure of
blindness
by a mer-
curial pow-
der.

Of univer-
sal medi-
cines.

of it. But till I be better satisfied about those particulars than yet I have been, I am unwilling either to seem to believe what I am not yet convinced of, or to assert any thing, that may tend to discourage human industry; and therefore I shall only venture to add on this occasion; that I fear we do somewhat too much confine our hopes, when we think, that one generous remedy can scarce be effectual in several diseases, if their causes be supposed to be a little differing. For the theory of diseases is not, I fear, so accurate and certain, as to make it fit for us to neglect the manifest or hopeful virtues of noble remedies, wherever we cannot reconcile them to that theory. He that considers what not unfrequently happens in distempered bodies by the metastasis of the morbid matter, (as for instance, how that, which in the lungs caused a violent cough, removed up to the head may produce, as we have observed, a quick decay of memory and ratiocination, and a palsy in the hands and other limbs) may enough discern, that diseases, that appear very differing, may easily be produced by a peccant matter of the same nature, only variously determined in its operations by the constitution of the parts of the body where it settleth: and consequently it may seem probable to him, that the same searching medicine, being endowed with qualities destructive to the texture of the morbid matter, where-ever it finds it, may be able to cure either all, or the greatest part, of the disease, which the various translation of such a matter hath been observed to beget. Moreover, it oftentimes happens, that diseases, that seem of a contrary nature, may proceed from the same cause variously circumstanced; or (if you please) that of divers diseases, that may both seem primary, the one is but symptomatical, or at most secondary in relation to the other; as a dropfy and a slow fever may, to unskilful men, seem diseases of a quite contrary nature, (the one being reputed a hot and dry, the other a cold and moist distemper) though expert physicians know they may both proceed from the same cause, and be cured by the same remedy. And in women experience manifests, that a great variety of different distempers, which by unskilful physicians have been adjudged distinct and primary diseases, and have been, as such, unsuccessfully dealt with by them, may really be but disguised symptoms of the distempers of the mother or *genus nervosum*; and may by remedies, reputed antihysterical, be happily removed. To which purpose I might tell you, *Pyrophilus*, that I, not long since, knew a practitioner, that with great success used the same remedies (which were chiefly volatile and resolving salts) in dropfies, and in (not, symptomatical, but) essential fevers. And our selves have lately made some experiments of not much unlike nature, with a preparation of hartshorn, of equal use in fevers and coughs, both of them primary. I might on this occasion recur to divers of the remedies formerly mentioned in several places of this essay; since divers of them have been found effectual against diseases, which, according to our common theory, seem to be little of kin one to another: and by telling you what I have observed concerning the various operations of *Helmont's laudanum*, of our *ens veneris*, and even of a medicine devised by a woman, the lady *Kent's powder*, I might illustrate what I have lately delivered: but it is high time for me to pass on to another subject; and therefore I shall rather desire you, in general, to consider, whether or no several differing diseases, and even some commonly supposed to be of contrary natures, be not yearly cured by the *Spaw waters in Germany*.

That the same matter may cause divers diseases.

And the same medicine cure them.

AND to assist you in this inquiry, I shall address you to the rare observations of the famous and experienced *Henricus ab Heer*, and to his *Spadacrene*; in the eighth chapter of which, he reckons among the diseases, which those waters cure, catarrhs, and the distempers, which (according to him) spring from thence; as the palsy, trembling of the joints, and other diseases of kin to these, convulsions, cephalalgæ, (I name them in the order, where I find them set down) hemicranæ, vertigo, redness of the eyes,

of

An instance
in the wa-
ters of the
Spaw.

of the face, the erysipelata, ructus continui, vomitus, singultus, obstructions, and even scirrhus, if not inveterate, of the liver and spleen, and the diseases springing thence; the yellow jaundice, *melancholia flatulenta seu hypocondriaca*, dropies, gravel, ulcers of the kidneys, and carunculæ in *meatu urinario*, gonorrhœas, and resembling affections, elephantiasis or the leprosy, *fluor albus mulierum*, cancers and scirrhus of the womb, fluxes and even dysenteries; the worms (though very obstinate, and sometimes so copious as to be voided in his presence, even with the urine) sterility, and not only the scabies in the body and neck of the bladder, and clammy pituitous matter collected therein, besides ulcers in the sphincter of it: but he relates, upon the repeated testimony of an eminent person, that he names, and one whom he styles *vir omni fide dignissimus*, that this party being troubled with a very great stone in his bladder, and having had it searched by divers lithotomists, before he came to the Spaw, did, by very copiously drinking these waters, find, by a second search made by those artists, that this stone was much diminished the first year, and (by the same way of trial) that it was so the second year. And of the cures of these diseases, the physician mentions in the same chapter, as to many of them, particular and remarkable instances; and in the beginning of the next chapter, having told his readers, that he expects they should scarce believe these waters can have such a variety of virtues, *Cæterum*, says he, *si in Spaa maturè & constantibus naturalibus, vitalibusque facultatibus venerint; aquasque quo dicemus modo biberint, indubitè quæ dixi vera esse fatebuntur.* And though we be not bound to believe (nor doth he affirm it) that the Spaw-waters do universally cure all the afore-mentioned distempers; yet it is very much, and makes much for our present purpose, that they should in so many patients cure most of these distempers, and lessen, if not cure, the rest. And we may somewhat the better credit him, because even where he reckons us the virtues of the Spaw, he denies it some, which other physicians ascribe to it. And it is very considerable, what he subjoins in these words: *Paucissimos enim vel nullos Spadæ incolæ capitis doloribus, cardialgiâ, calculo, obstructionibus renum, hepatis, lienis, mesaraicarum, laborantes invenies; îtêricos, hydrogicos, podagricos, scabiosos, epilepticos, quod sciam, nullos:* ‘You will find very few of those, who dwell at the Spaw, who are troubled with the head-ach, stone, obstructions of the kidneys, liver, spleen, or mesaraick veins; none at all, who were troubled with the jaundice, dropy, gout, itch, or falling-sickness.’ But that, which I most desire you to take notice of, is, that besides all the above-mentioned diseases, I find, that he ascribes to these waters the virtues of curing such, as are counted of a contrary nature, and are thought to require contrary remedies. For besides that, he expressly affirms, in the beginning of the eighth chapter, that these waters being endowed with the virtues both of hot and cold minerals, they cure both hot and cold affections, in the same patients, and in differing bodies, and that contrary effects are performed by them; he hath, after some pages, this passage, which may go for an illustrious proof of that he hath asserted: *Inter cætera* (saith he, speaking of the Spaw-waters) *mensibus movendis in primis idonea, quod millies experientia comprobavit: et tamen nimium eorum fluxum quovis alio medicamento felicius sistit.* ‘Among other qualities, it moved the monthly evacuations, as hath been proved by a thousand trials: and yet it stops the immoderate flux of them more happily than any other medicine.’

THESE testimonies, *Pyrophilus*, of our experienced author would perhaps obtain the more credit with you, if you had seen what I lately had the opportunity to observe in a hot and dry season at our own Tunbridge waters in Kent, when I was there to drink them. And therefore I shall again invite you not only to consider, whether one potent remedy, such as it may be, may not be able to cure variety of diseases, and

and some supposed to be of contrary natures; but whether or no divers persons, on whom the received *methodus medendi* hath been long and fruitlessly employed, be not by their tired and despondent physicians themselves sent thither, and there cured of their abstruse and obstinate diseases, by remedies prepared by nature without the assistance of art: for if you duly reflect on this conspicuous observation, and consider, how much it is possible for art to meliorate and improve most (especially mineral) remedies, afforded us by nature, you would probably dare to hope, that medicines might be prepared of greater efficacy, and applicable to more diseases, than they, who think the more received theory of diseases (from which yet very eminent physicians, in divers particulars, scruple not to recede) incapable of being rectified; and that judge of all remedies by them, that are publicly venal in apothecaries shops, will allow themselves so much as to hope.

If now you demand, *Pyrophilus*, If I think that every particular, which hath contributed to swell this discourse into a bulk so disproportionate to that, which the title of an essay promised, to directly belong to the art of physick? I shall leave it to the judicious *Celsus* (whom learned men have styled the Roman *Hippocrates*) to answer for me, and he will tell you, that *quanquam multa sint ad ipsas artes non pertinentia, tamen eas adjuvant excitando artificis ingenium*. I suppose I need not remind you, *Pyrophilus*, that it was not my design, in what hath been represented, to subvert those principles of the *methodus medendi*, from which no sober physicians themselves recede, and in which they unanimously acquiesce; and that I much less intend to countenance those venturous empiricks, who, without any competent knowledge of anatomy, botanicks, and the history of diseases, think receipts or processes alone can enable them to cure the sicknesses they know not, and who would persuade men to lay by, as needless, a profession, of whose usefulness to mankind, we may elsewhere have occasion to discourse. No, *Pyrophilus*, without peremptorily asserting any thing, I have but barely represented the notions I have mentioned concerning the *methodus medendi*, as things probable enough to deserve to be impartially considered; that in case they prove fit to be declined, they may appear to have been rejected, not by our superciliousness or laziness, but (after a fair trial) by our experience: and in case they seem fit to be approved, they may prove additional instances of the usefulness of natural philosophy to physick. Which usefulness, *Pyrophilus*, if I have in any considerable measure been so happy as to make out, I shall not think the time (and much less the pains) I have bestowed upon that theme, mispent. For, I must confess to you, *Pyrophilus*, that to me it seems, that few things ought more to endear to us the study of natural philosophy, than that (according to the judicious sentence of our *Celsus*, *Rerum naturæ contemplatio*, saith he, *quamvis non faciat medicum, aptiorem tamen medicinæ reddit* :) ‘The contemplation of nature, though it maketh not a physician, yet it fits him to learn physick:’ A deeper insight into nature may enable men to apply the physiological discoveries made by it (though some more immediately, and some less directly) to the advancement and improvement of physick.

AND I well enough know, *Pyrophilus*, that instead of writing the essay to such a one as you, if I should write it to the more critical and severer sort of readers, they would be apt to think, both that it is impertinent for me, who do not profess to be a physician, to treat prolixly of matters medicinal; and that it may appear somewhat below me, in a book, whose title seems to promise you philosophical matters, to insert I know not how many receipts. But I shall not scruple to tell such a person as *Pyrophilus*, that since my method required, that I should say something to you of the therapeutical part of physick, I thought, that Christianity and humanity it self obliged me not to conceal those things, which, how despicable soever they may seem to a speculative philosopher,

Of the reason and design of the author's discourse concerning the *Methodus medendi*, and his descending to other particulars, which may be thought improper for him.

are

are yet such, as, besides that some of them may perhaps afford improveable hints touching the nature of remedies, if not also of diseases, experience hath encouraged me to hope, that others may prove useful to the sick. And as for the inserting of receipts, even in books of philosophical subjects, I have not done it altogether without example. For not only *Pliny*, a person of a great dignity as well as parts, and friend to one of the greatest Roman emperors, hath left us in a book, where he handles many philosophical matters, store of particular receipts; but our chancellor, the Lord *Verulam*, hath not disdained to record some. And as to that industrious benefactor to experimental knowledge, the learned and pious *Mersennus*, his charity made him much more fearful to neglect the doing what good he could to others, than to venture to lessen his reputation by an *indecorum*, that in a mathematical book, and in a chapter of arithmetical combinations, he brings in not only a remedy against the erysipelas, but even a medicine for corns, where he tells us, that they may be taken away, by applying and daily renewing for ten days, or a fortnight, the middle stalk, that grows between the blade and the root (for that I suppose he means by the unusual word *thallum*) of garlick, bruised. Nor is it without examples, though somewhat contrary to my custom in my other writings, that in this, and the four precedent essays, I have frequently enough alledged the testimonies of others, and divers times set down processes or receipts, not of my own devising. For even among professed and learned physicians, scarce any thing is more common, than on subjects far less of kin to paradoxes, than most of those I have been discoursing of, to make use of the testimonies and observations of other approved writers, to confirm what they teach. And not now to mention the voluminous books of *Schenkius Scolzius*, that famous and experienced practitioner *Riverius* himself hath not been ashamed to publish together a good number of receipts, given him by others, under the very title of *Observationes communicatæ*: and *Henricus ab Heer* hath, among his *Observationes oppido raræ*, divers receipts, that came from mountebanks, and even gypsies. And therefore I hope, that you, who know, that it is not after every body, that I would so much as relate an observation, or mention a medicine, as thinking them probable, will easily excuse one, that hath much fewer opportunities, than a professed physician, to try remedies himself; if treating of subjects not so familiar, I choose to countenance what I deliver by the testimonies of skilful men, and if I scruple not to preserve in these papers some not despicable remedies, as well of abler men, as of my own, that otherwise would probably be lost. But of this practice I may elsewhere have occasion to give you a more full apology, by shewing, how much it may conduce to the enriching and advancement of physick; an art, with whose praises I could long entertain you, if I were at leisure (and durst allow myself) to exhaust common places.

AND yet give me leave to tell you, that man is so noble a creature, and his health so requisite to his being able to relish other goods; and oftentimes also to the comfortable performance of what his conscience, his country, his family, his necessities, and perhaps his allowable curiosity challenge from him, that I wonder not so much at those antient heathens, that, being polytheists and idolaters, thought themselves obliged, either to refer so useful an art, as that of physick, to the gods, or godlike persons; or to add those, that excelled in so noble a faculty, to the number of those they worshipped. For my part, *Pyrophilus*, a very tender and sickly constitution of my own (much impaired by such unhappy accidents as falls, bruises, &c.) hath, besides (as I hope) better motives of compassion, given me so great a sense of the uneasinesses, that are wont to attend sickness, that I confess, if I study chymistry, it is very much out of hope, that it may be usefully employed against stubborn diseases, and relieve some languishing patients with less pain and trouble, than otherwise they are like to undergo
for

for recovery. And really, *Pyrophilus*, unless we will too grossly flatter our selves, we can scarce avoid both discerning and deploring the ineffectualness of our vulgar medicines, not only Galenical, but chymical, (for an active body may yet be but a languid remedy). For besides that many, that recover upon the use of them, endure more for health, than many, that are justly reckoned among martyrs, did for religion; besides this, I say, we daily meet with but too many in the case of that bleeding woman, mentioned in the Gospel, of whom it is said, that she had suffered many things of many physicians, and had spent all that she had, and was nothing bettered, but rather grew worse. And therefore I reckon the investigation and divulging of useful truths in physick, and the discovering and recommending of good remedies, among the greatest and most extensive acts of charity, and such, as by which a man may really more oblige mankind, and relieve more distressed persons, than if he built an hospital. Which perhaps you will not think rashly said, if you please but to consider, how many the knowledge of the salivating, and other active properties of mercury, and of its enmity to putrefaction and distempers springing thence, have cured of several diseases; and consequently how many more patients, than have recovered in the greatest hospital in the world, are obliged to *Carpus*, and those others, whoever they were, that were the first discoverers of the medical efficacy of quicksilver. And for my own particular, *Pyrophilus*, though my youth and condition forbid me the practice of physick, and though my unhappy constitution of body kept divers remedies from doing me the same good they are wont to do others; yet having more than once prepared, and sometimes occasionally had opportunity to administer medicines, which God hath been so far pleased to blefs on others, as to make them relieve several patients, and seem (at least) to have snatched some of them almost out of the jaws of death; I esteem my self, by those successes alone, sufficiently recompensed, for any toil and charge my inquiries into nature may have cost me. And though I ignore not, that it is a much more fashionable and celebrated practice in young gentlemen, to kill men, than to cure them; and that mistaken mortals think it the noblest exercise of virtue to destroy the noblest workmanship of nature, (and indeed in some few cases the requisiteness and danger of destructive valour may make its actions become a virtuous patriot) yet when I consider the character given of our great master and exemplar, in that scripture, which says, *That he went about doing good, and healing all manner of sickness, and all manner of diseases among the people*; I cannot but think such an employment worthy of the very noblest of his disciples. And I confess, that if it were allowed me to envy creatures so much above us as are the celestial spirits, I should much more envy that welcome angel's charitable employment, who at set times diffused a healing virtue, through the troubled waters of *Bethesda*, than that dreadful angel's fatal employment, who in one night destroyed above a hundred and fourscore thousand fighting men. But of the desirableness of the skill, and willingness to cure the sick, and relieve not only those, that languish in hospitals, but those that are rich enough to build them, having elsewhere purposely discoursed, I must now trouble you no longer on this theme, but implore your much-needed pardon, for my having been (beyond my first intentions) so troublesome to you already.

Mark v. 26.

That this employment is better than the more fashionable of destroying valour.

Acts x. 38. Mat. iv. 24.

Joh. v. 14. 2 Kings xix. 35. The angel's charitable employment at Bethesda more desirable than his, who destroyed in one night 180,000 fighting men.

A N

A P P E N D I X

T O T H E

FIRST SECTION of the SECOND PART.

Advertisements touching the following APPENDIX.

I SCARCE doubt, but it will be expected, that I should annex to the foregoing treatise those receipts and processes, which seem to be here and there promised in it: But I desire it may be considered, that some passages, which an unattentive reader may have mistaken for absolute promises, are indeed but promises conditionally made, to a particular person; and so not engaging me, till the condition (which was his desiring the thing mentioned to him) be on his part performed. And as for the other things, which every reader may suppose to be promised him, I have at hand this general excuse; that at least I promised nothing to the publick, whatever promises I may have made in the foregoing Essays, having together with them been addressed to a private friend. And I have two or three special reasons to insist on this excuse; for divers of my choicer books and papers having not long since unhappily miscarried through the negligence of some men, and fraud of others, it is not now possible for me to retrieve some of the things I was master of, when I promised them. And then to revise carefully all the papers, that remain in my hands, of affinity with the past treatises, would take up more time, than is allowed me by other studies and employments, which I think of greater moment, or at least wherein I am much more concerned, than to give this book at present a full or accurate Appendix.

BUT though I might, upon these and other reasons, wholly excuse my self from the trouble of adding any appendix; yet because the communicating of good medicines is a work of charity, and those unpolished and immethodical notes, that may perchance disparage an author, may yet relieve many a patient; I am willing to do what my occasion will permit: and finding among my papers many loose sheets, concerning spirit of harts-horn, blood, &c. written divers years since to a friend, I chuse rather to publish them just as I find them with *Pyropbilus's* name, employed in convenient places, and to add some unpromised receipts in stead of those, that are lost, than be altogether wanting to what may be expected from me. I know, that what I deliver concerning some of the following preparations, may by severer criticks be thought somewhat unaccurate, and I confess I am of that mind my self; but meeting with these collections in loose sheets among my old papers, I must either publish them as I find them, or take the pains to polish and contract them; which would require more time, than I can at present afford them. And much less can I stay to subjoin the histories of the particular cures performed by the medicines, whose preparations I set down, though divers of them would not perhaps appear inconsiderable. But if I find by the entertainment of these papers, that it will be worth while to revise or enlarge them, I may, God permitting, be invited to do it, and either supply the things,

things, that are here deficient, out of after observations, or papers now out of the way, or make amends for their omission in substituting better things.

It will not at all surprize me, if some readers think me too prolix in delivering the preparations of harts-horn, ens Veneris, &c. with such particular and circumstantial observations. But my design being to gratify and assist those that would make and use the remedies I recommend, the experience I have had of the difficulties most men find in the preparing things by the direction of chymical processes not very expressly set down, makes me apt to hope, that (I say not the great physicians or chymists, who may, if they please, leave them unperused; but) those for whom I principally intend my directions, will think my having made them so particular a very excusable fault. And I make the less difficulty to suffer such things, as perhaps I judge to be, in comparison of others, but trifles, to pass abroad; because finding of late years, that many persons of quality of either sex, who scarce read any other than English books, have (as I hope) out of charity, or curiosity, or both, begun to addict themselves to chymistry, and venture to be tampering with spagyric remedies; it may not be unseasonable to supply them with some preparations, that may both save them time and charges, and put them upon the use of remedies, which, without being languid, are, if any thing discreetly given, safe and innocent, and wherein a little error either in the making or the administering will be far less prejudicial to the sick, than if it were committed in the more vulgar (oftentimes, either falsely or obscurely prescribed) preparations they are wont to make of acid salts, mercury, antimony, and other minerals; whose activity for the most part makes them need to be skilfully prepared and judiciously given.

To the 96th Page.

The Irish lithotomist's receipt, for the stone in the bladder.

REC. *Aquar. melon. citrullor. filipendulæ, petroselin. syr. è 5 radicibus, syr. de By-santiis, ana unc. ij. oxymelit. comp. unc. j. misce; quartam mixti partem sumas manè jejunos, & postea per octo horas à cibo & potu abstineas, aliam sumas partem eodem die post cænam cum lectum intrare volueris. Denique sequenti die reliquæ sumantur partis ut primæ; tertio verò die,*

REC. *Elect. lenit. drachm. iij. syr. rosct. solut. drachm. ij. pulp. tamarind. drachm. j. misceantur ac in seri lactis unc. iij. dissolvantur: totum bibas mane quatuor horis antè jus, quarto die sumas mane sequentis pulv. drachm. j. mixti insequentis apozematis unc. iij. & olei amygd. dulc. unc. sem.*

REC. *Cinerum vitri, & scorpionum pulveris lapid. spongiæ, & lap. Judaici, acori, sem. albicæ, millii solis, saxifragii ana drachm. j. sem. lactucæ, 4 sem. frigid. majorum ana drachm. sem. trochiscor. alkekengi, rad. pimpinellæ ana drachm. ij. fiat pulvis subtilis.*

Apozema.

REC. *Parietaræ, rad. alth. ana m.j. sem. petroselini, glycyrrhiza ana unc. sem. haliacabi unc. j. coq. in aq. pluvie sext. 2. & vini albissimi sext. j. ad medietatis consumptionem, & colatura melle bybernico dulceretur.*

Tum quarto illo die passerculum trogloditem sale antea conditum edas una cum cæna, et post cænam lumbi, pubes, & tota renum regio oleis è granis citri & scorpion. liniantur, etsi possibile esset prædicta olea per meatum urinar. in vesicam injiciantur, sitque dein è pulvere, apozemate, troglodite & oleis omni die utere, donec arenulæ aut lap. fragmenta una cum expulsis apparuerint.

Loco cinerum vitri sumi possunt cineres camini & vires cinerum scorpionum supplere potest pulvis lumbricor. terrestr. probè in vino lotorum & postea exsiccatorum.

N. B. [As far as I could conjecture by the discourse I had with the owner of the receipt, by ashes of glass he means the superfluous saline substance, which the glass-men are wont to call *Sandiver*; but because he did not explain himself so clearly, and we know not yet a way of burning glass to ashes, I think it will be most advisable to substitute the wood-ashes, which in the receipt it self towards the close of it are appointed for a succedaneum.]

To the 115th Page.

[Where the Virtues of the *Pilulæ Lunares* are touched at.]

THE great benefit, that has redounded to many patients, from the use of the silver pills, here briefly mentioned, and commended, invites me to communicate, as a considerable thing, the preparation of them, of which I do not pretend to be the inventor; having, divers years since, learned it by discoursing with a very ancient and experienced chymist, whose name, that I do not mention, will perhaps seem somewhat strange to those readers, that have observed me not to be backward in acknowledging my benefactors in point of experiments; and therefore I hold it not amiss to take this opportunity of declaring once for all, that it were oftentimes more prejudicial than grateful to one, that makes an advantage by the practise of physick, to annex in his life-time his name to some of his receipts or processes; because that when a man has once got a repute for having a specifick in any particular disease or case, his patients and their friends will hardly forbear to apply themselves to him for that medicine, though the same medicine, but not known to be the same, should be made use of by a stranger, or divulged in a printed book; most patients being not apt to rely upon medicines, that come only that way recommended; whereas if it were known, that the printed receipt is the self-same, which the physician employs, not only other physicians would quickly make as much advantage of it as he, but many patients would think themselves by that discovery dispensed with, in point of good husbandry, from going to any physician at all; as knowing beforehand the best prescription they are like to receive from him: The process of the *Pilule lunares* is this:

The preparation of the *Pilulæ lunares*.

TAKE of the best refined silver as much as you please, dissolve it into a sufficient quantity of cleansed spirit of nitre, or aqua fortis; then evaporating away the superfluous moisture, let the rest shoot into thin crystals: these you may in some open-mouthed glass place in sand, and keep in such a degree of heat, that by the help of very frequently stirring them, the greatest part of the more loose and stinking spirits of the menstruum may be driven away, and yet the remaining crystals not be brought to flow: these crystals of silver you must counterpoise with an equal weight of crystals of nitre; and first dissolving each of them apart in distilled rain-water, you must afterwards mingle the solutions, and abstract or steam away the superfluous moisture, till the remaining mass be dry; which you must keep in an open glass, exposed to such a temperate heat of sand, that the matter may not melt (which you must be very careful of) and that yet the adhering corrosive spirits of the menstruum might be driven away. And to both these ends you must from time to time stir the mass, that new parts of it may be exposed to the heat, and new ones to the air, till you cannot descry in the remaining white powder any offensive scent of the spirit of nitre, or of the aqua fortis. And lastly, you must take the crumb of good white bread, made with a little moisture into a stiff paste, and exactly mingle with the newly mentioned magistery or powder as much of this paste, as is necessary to give it the consistence of a mass of pills, which you may thence form at pleasure, and preserve in a well-stopped glass for use.

N. B. FIRST,

N. B. FIRST, the silver employed in this operation ought to be very pure and more exquisitely refined, than much of that is wont to be, which here in *England* is bought for fine silver; for if the copper, wherewith silver-coins are wont to be alloyed, be not carefully separated upon the cupel, it may, being turned by the acid menstruum into a kind of vitriol, when it is taken into the body, either provoke vomits, or otherwise discompose it.

SECONDLY, the spirit of nitre, or (which in our case comes almost to one) the aqua fortis, that is used about this medicine, ought to be cleared, as our refiners phrase it, before the silver be put in; for (as I elsewhere note) in salt-petre there is oftentimes an undiscerned mixture of sea-salt, whose spirit coming over in distillation with that of nitre, is apt to precipitate the silver, which the spirit of nitre has dissolved. This I take to be the reason of that practice of the best refiners to purify their aqua fortis, by casting in some small piece of silver, that they may afterwards securely put into it greater quantities of the same metal to be dissolved. For the saline spirits fall to the bottom, together with the corroded silver, which they precipitate as long as there is any of these saline spirits left in the menstruum, which after this may be decanted clear; and though you had put a little more silver than needed to it, it neither does harm nor is lost, the aqua fortis preserving none unprecipitated, but what there were no more saline spirits to work upon; so that the superfluous silver put in is already dissolved to your hand.

THIRDLY, the dry mixture obtained from the solutions of crystals of nitre, and crystals of silver, must be often stirred and kept longer in the sand, before all the offensive spirits will be driven away, than, till experience had informed me, I did imagine.

FOURTHLY, if the crystals of silver be considerably blue or green, it is a sign the silver was not sufficiently purged from copper; else the mixture we have been speaking of, will look of a white, good enough. And possibly it was by reason of the not being careful to take sufficiently refined silver, and of the not knowing how to improve the crystals of silver, by the addition of those of nitre, and especially how to free them from the stinking and corrosive spirits of aqua fortis, that it is come to pass, that though there being some chymical writers processes not very unlike this, yet the crystals of silver have been censured and laid aside, as not always safe, even by those, who otherwise much magnify the efficacy of those they used.

FIFTHLY, when you are about to make up this mixture with the crumb of bread into a mass, and so into pills, it will not be amiss to dispatch that work at once; for usually it leaves an ugly blackness on the fingers, that cannot under divers days be gotten off.

SIXTHLY, in taking of the pills care must be had, that they be sufficiently lapped up either in a wafer wetted with milk, or the pulp of a roasted apple, or some such thing, that they may not touch the palate, or the throat, because of the extreme and disgusting bitterness, which is to be met with in the crystals of silver, and which is not the least thing, that with nicer persons does blemish these pills.

SEVENTHLY, the dose is somewhat uncertain; because they work much according to the constitution of the body, and especially according as it abounds with ferous humours: wherefore it is adviseable to make the pills of the size of very small peas, of which one given at bed-time is a sufficient dose for some bodies, others will require two; and in some we must ascend to three: and if the patient be hydro-pical, or be otherwise much molested with ferous humours, it is observable, that sometimes one dose will work two days, or four days, (may be five or six) successively,

The dose
and use of
these pills.

sively, but yet moderately and usually, without weakening the patient, in proportion to such copious evacuations.

EIGHTHLY, Besides the dropfy, wherein we have mentioned this remedy as a specifick, it often proves very available in other cases, wherein men are troubled with ferous humours. But the first distempers, which I heard it magnified for, were those of the head, and *Genus nervosum*; and a great virtuoso of my acquaintance, that inherits a disposition to the pally, has several times told me, that if when he begins to find himself disordered, he takes a dose of these pills, he is thereby constantly relieved. But of the particular cases, wherein we have had opportunity to take notice of their effects, we have not now, but may perchance another time, have leisure to entertain you.

LASTLY, That skilful and successful chymist Dr. N. N. who doth much both use and esteem this remedy, being desired by me to let me know, if he had any objections against it, informs me, that when he hath given these pills oftentimes, and without intervals, though they did not either salivate or vomit, or much weaken the patient, yet they would at last be attended with a kind of incipient leucophlegmatia, which he easily prevents by intermitting for a while the use of the pills, after every second or third time, that he administers them, and giving, when he expects it to be requisite, some *Crocus Martis*, extract of juniper, or other astringent or hepatick medicines, to corroborate the viscera, and preserve their tone.

To the 116th Page.

(Where mention is made of the cure of one, concluded to have a gangrene, by an inward medicine.)

THE cure mentioned in this place having been performed by that medicine, which from the name of that great commander as well as virtuoso, who was the author of it, passes under the name of Sir *Walter Raleigh's* cordial, and this being but one of many remarkable (and some of them stupendous) cures, which have been wrought by it from time to time, especially of late, that it hath been more used, I am induced to annex here the yet unpublished receipt; partly, because there are divers receipts, that are each pretended to be the true, magnified by their several possessors; and I had the liberty of looking it out in a receipt-book, preserved by the author's son; and partly because, though I will not affirm, that a skilfuller or more promising composition of the same ingredients could not have been devised, yet the following receipt has been abundantly recommended by experience. And I remember, that but a while since a person of note having sent to me, to desire a taking of this cordial for a certain knight, who after all that skilful physicians could do, had long lain a dying; I the other day chanced to meet this knight at *White Hall*, well, lively, and with a face, whose ruddiness argued a perfect recovery, and yet he is not very far from seventy years of age, and had, before he grew so ill, long conflicted with a tedious ague, and fever, which had reduced him to that extremity, when the cordial was brought, that, as himself told me, he neither was sensible, when they gave it him, nor had known what he did, or what was done unto him, during the space of several days before.

Sir *Walter Raleigh's* cordial, after Sir R. K. his way, (set down verbatim, as I the author received it.)

TAKE burrage-flowers, rosemary-flowers, marigold-flowers, red july-flowers, rosa-folis, elder-flowers, of each one pottle, after they are dried in the shade.

TAKE also of scordium, carduus, angelica, balm, mint, marjoram, fetwall, betony, *ana* four handfuls; after they are dried in the shade.

TAKE also of the rinds of sassafras of *Virginia*, lignum aloes, *ana* four ounces beaten to powder; of kermes, cubebs, cardamoms, zedoary, *ana* one ounce; of saffron half an ounce; juniper-berries, tormentil-roots, round birthwort roots, of each one ounce; of gentian-roots half an ounce.

DRAW the tincture or extract of these with spirit of wine in *balneo*, and save all the ingredients, after you have taken out the tinctures, and burn them, and put their salt into their tinctures.

TAKE six ounces of the extracts of all these with their salt, and put thereto of the tincture of coral three ounces; terra sigillata four ounces; pearl prepared two ounces; bezoar-stone three drachms, hartshorn calcined four ounces, ambergrease four drachms, musk *gr.* xxx; sugar-candy one pound and an half, ground very fine, and searfed through a fine searfe.

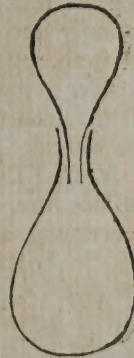
THEN the musk and amber must be ground, and by little and little mingled with it; the more you grind the amber, the better.

THEN put to the sugar-candy all the dry materials before directed, and make all as small as possibly you can.

THEN upon a great hollow grinding-stone mingle the tinctures, and dry things together; (which must be done by a strong man used to that work :) and whilst it is in grinding, put of syrup of lemons, and syrup of red roses equal parts into it, else it will be so dry, that it will neither grind nor mingle.

How to make the tincture of Coral for this Cordial.

TAKE eight ounces of coral, and put it unbeaten into a calcining pot unluted, and let it stand twenty four hours in a calcining or glass-furnace, till the coral be as white as snow; then put it in three quarters of distilled vinegar in a long glass with a narrow mouth, and with another small glass or phial put into the mouth of it, the belly upwards, to save the vinegar from waisting, thus: and set in a sand-furnace, so as the sand may be as high as the vinegar.



LET it boil without intermission twenty-four hours, by which time the vinegar will become red; so, when it is cold, pour off the vinegar into a glass-bason, or a bell-glass, and vapour away all the vinegar in *balneo*, and gather the coral, being perfectly dry, for your use. You may strike down your pearl with oil of vitriol, and oil of sulphur, equal parts, which is accounted the best way to prepare the pearl: but Sir R. K. did use to prepare his pearl by juice of lemons.

[THE dose for a man is about the bigness of a small hazel-nut; but where prevention is only aimed at, or some such use as the dissipating the fumes of the spleen, as they call it, the bigness of an ordinary pea may suffice; so in urgent cases the dose may be increased to the quantity of a nutmeg. It is usually given by it self upon an empty stomach (the patient being kept warm after it, to promote sweat) in fevers, want of spirits, violent fluxes, and several other distempers, where diaphoreticks, and antidotes are proper, and (especially) potent cordials are required.

[To

[To the 116th Page,
Where a receipt that cured fistulas is mentioned.]

A water for a fistula, and all manner of wounds and swellings, or old ulcers, cankers, tetters, boils, or scabs in any place, or green wounds.

TAKE of bole-armoniack four ounces, of camphire one ounce, of white vitriol four ounces; boil the camphire and the vitriol together in a little black earthen pot, till they become thin, stirring them together, till they become hard in setting; then bruise them in a mortar to powder, and beat the bole-armoniack it self to powder, and then mingle them together, and keep the powder in a bladder, till such time you use it. Then take a pottle of running water, and set it on the fire, till it begin to seeth; then take it from the fire, and put in three good spoonfuls of the powder into the water whilst it is hot, and after put the water and powder into a glass, and shake it twice a day, to make the water strong: but before you use it, let it be well settled and very clear, and apply it as hot as the patient can well suffer it; and lay a clean linnen cloth, four double, to the sore, it being wet in that water, and bind it fast with a roller to keep it warm; do it morning and evening, till it be whole. This water must be put into an oyster-shell, not in a saucer, when you dress the sore, for the pewter will suck it up. Remember you put three as good spoonfuls of powder as you can press into the spoon. Take heed no one drink of this water, for it is poison. To make it stronger, beat an ounce of alum to powder, and mingle it with the other powders.

TAKE of bole-armoniack half an ounce, white vitriol one ounce, of camphire two ounces, make them all into powder; then take a pottle of smiths-water, and as much spring-water, and mingling them, set them upon the fire. As soon as it begins to seeth, put in the powder very softly, stirring it all the while: as soon as the powder is in, take it off the fire, and dress the wound with it twice a day, laying a cloth folded four times and wetted in the water, it being very hot, and so applied to the wound.

N. B. [This is the receipt *verbatim*, as I find it among my old papers, but I am not sure, that among those I cannot now come by, there may not be something concerning a way of making a small pliable tent, that may accommodate it self to the crooked figure of the cavity of many fistulas. For methinks I remember, that the surgeon prescribed the conveying the medicine by the means of such a flexible tent a great way into the cavity, if not to the bottom of the fistula, which was thereby to be cleaned.]

To the 129th Page.
Where soot is mentioned.

SOOT, *Pyrophilus*, is a production of fire, whose nature is almost as singular, as is the manner of its being produced; for it is (if I may so call it) a kind of volatile extract of the wood it proceeds from, made instead of a menstruum by the fire, which hastily dissipating the parts of the body it acts on, hath time enough to sever it into smaller particles, but not leisure and aptitude to reduce it into such differing substances, as pass for chymical or peripatetick elements; but hastily carries up the more volatile parts, which being not yet sufficiently freed from the more fixed ones, take them up along with them in their sudden flight, and so the aqueous, spirituous, saline, oleaginous and terrestrial parts ascending confusedly together, do fasten themselves to the sides of the chimney in that loose and irregular form of concretion, which we call soot: an inquiry into whose nature, as it may be considered in
the

the survey of the distinction of salts, must be elsewhere looked for; our mentioning it at present being only to take occasion to tell you, that, as ill-scented and despised a body as it is, *Hartman* (one of the most experienced and happy of chymical writers) scruples not to reckon the spirit and oil of it among the noblest *confortantia*; such as prepared pearl, coral, amber-greese, and other eminent cherishers of nature. His preparation is for substance this: Take of the best foot, (such as adheres to the lower part of the chimney, and shines almost like jet) what quantity you please, and with it fill up to the neck a very well-coated glass retort, or an earthen one, and luting on a capacious receiver, distil the matter in an open fire intended by degrees, whereby you will drive over the phlegm, the whitish spirits, and the oil, first of a yellow colour, and then of a red; separate the phlegm, and for a while digest the spirit and the oil together, on which afterwards put half the quantity of spirit of wine, and distil them several times, whereby you will obtain, together with the spirit of wine, the spirit of foot, and also a very depurated oil, smelling like camphire. Out of the calcined *caput mortuum* after the common way extract a salt, which *Hartman* commends as a most excellent curer of exulcerated cancers: this salt, saith he, is drawn with vinegar; in which liquor, in a cold moist place, it is again dissolved; and therewith the cancerous ulcers being once or twice anointed, the venosity will be visibly drawn out like a vapour, and then the fore-mentioned oil being lightly sprinkled upon the place, will breed on it a kind of crust like a skin, which spontaneously coming off in five or six days, will, by its falling off, argue the consolidation of the ulcer. What this so extolled remedy will perform, I know not, having never made trial of it, nor thinking it very likely, that a bare alcalizate salt should have such specifick virtues; nor is it requisite I should insist on it, being here to discourse to you of the distilled liquors of foot; in prosecution of which design, let me tell you, that *Hartman* prescribes the administering of the spirit from six to ten grains, of the oil from two or three drops in wine, or any other convenient vehicle: and concerning the oil he adds, that if three drops of it be given in vinegar to an almost gasping man, he will be thereby wonderfully refreshed, and as it were revived; to which he annexeth this prognostick, that if the remedy produceth copious sweats, it will recover the taker; but if not, he will die.

Hartman's
preparation
of spirit and
oil of foot.

Hartm.
Prax.
Chym.
p. 12.

THAT this spirit of foot, described by *Hartman*, may be a very good medicine, I am very apt to think; but because it is not a meer spirit of foot, but a mixed one of spirit of wine, and spirit of foot, we have rather chosen to proceed with the foot (of wood) without addition, both as to the distillation of it, and the ordering of the distilled liquors, after the manners to be mentioned ere long, when we shall acquaint you with our preparations of blood and hartshorn; which if you please to apply to foot, you may save your self, and me, the labour of repetitions. Yet it may not be amiss to advertise you here of two things: the one, that if you employ very good and fat foot, and fill up the retort with it to the neck, you must be very careful to increase the fire orderly, and but by moderate degrees; or else you may chance to make the matter boil over out of the retort into the receiver; as it lately happened to us, when having warily ordered the fire for several hours, we thought ourselves past any such danger: and the other, that as to the medicinal virtues of the spirit, and salt of foot, I shall not now particularize them; partly that I may save time, and partly because they may be well enough gathered from their affinity to the volatile salts and spirits of animal substances hereafter to be treated of; and from what I shall have occasion to say, of the perfuming of the salt foot, towards the close of this Appendix.

The au-
thor's di-
rections
concerning
preparations
from foot.

To the 130th Page.

Of the uses
of the pre-
parations of
urine.De Lithiaſt.
c. 3. n. 3.

URINE is a body, which, as homely and deſpiſed as it is wont to be, may, by ſkilful ways of ordering it, be made either alone, or in conjunction with other ingredients, to afford ſuch a variety of uſeful ſubſtances, that I find *Reuſnerus* publiſhed an entire treatiſe, which yet I never could get ſight of, under the title of *Synopſis remedium ex urina præparatorum*, beſides what other chymiſts have ſince divulged on the ſame ſubject, which I forbear to mention; becauſe ſeveral of them I have not tried, and many others I think ſcarce worth trying. But becauſe even all our own obſervations, concerning the preparations and uſes of things afforded by urine, would take up more time and room, than I can now allow them, I ſhall here only take this occaſion to intimate thus much in general, that the ſpirit and ſalt of urine may be made far greater uſe of, than men yet are prone to think; not only in phyſick, but in chymiſtry, and perhaps I durſt add in natural philoſophy too. And though *Helmont* be not wont to lavish his praiſes upon worthleſs remedies, yet he calls it *nobile ad iſterum, alioſque morbos, remedium*. And in another place, ſpeaking of the ſaline cryſtals of urine, he hath this expreſſion: *Quæ quanquam ad veteres excrementorum oppilationes conſerunt, nihil tamen adverſus lithiaſin*; which ſeems, by denying to the ſalt of urine ſome virtues aſcribed to it by many other chymiſts, to bring ſome credit to his praiſes of it. (And indeed a friend of mine, that has tried it in the jaundice, affirms it to deſerve the commendation he gives it in that diſeaſe.) And though I fear our author hyperbolizeth, where he (elſewhere) thus writes; *ſpernit eos ſapientia* (he means ſure that, which is proper to the Spagyriſts) *qui materiam ex qua diſpoſitiones, contenta, proprietates, progreſſum & ſignificationes lotii addiſcere recuſarent per ignem*: yet perhaps the hyperbole is not altogether ſo extravagant, as moſt readers will think it. And I remember, that a while ago, conſerring with a publick miniſter of a foreign prince, who is a very inquisitive and experienced perſon, he freely told me, that though he had travelled very much, and divers times not in a capacity, yet the greateſt chymiſt, that ever he could make acquaintance with, uſed to tell him, that ſalt of urine was ſo precious a thing, that it was a pity it ſhould be uſed in ordinary diſeaſes: but what his reaſons were for valuing it ſo much, he would not declare, and therefore I ſhall lay no great weight upon his teſtimony. And yet I muſt not at this time particularly declare, upon what account it is, that I do ſo value the volatile ſalt of urine, of whoſe virtues (whiſt it is ſingle) I ſhall only in a word obſerve to you now (what is pertinent to the occaſion of my mentioning it at preſent) namely, that when it is well prepared [*according to the way plainly enough, though but very briefly touched already*] it differs ſo little in ſmell, taſte, volatility, penetrancy, and ſome other manifeſt qualities, from the ſalt of hartſhorn, and that of man's blood; that ſuch effects, though perhaps ſomewhat leſs powerful, may be not improbably expected from it, as are produced by the other.

To the 131ſt Page.

Of the pre-
parations of
man's blood.

Though I have not in this place made any abſolute promiſe, of annexing any thing more particular touching the ſpirit of blood; and though I cannot now find, and I fear may have loſt thoſe of my papers concerning that ſubject, which were the leaſt unaccurate: yet, ſetting aſide former trials, a recent account brought me by a phyſician, whom I had entruſted with ſome of it, repreſents it as ſo very good a medicine, that I am content to ſubjoin, what particulars I have lately found among my looſe papers concerning it, as I many years ago ſent them to a friend; and this I rather do, becauſe there being annexed to the proceſs divers obſervations of general import to ſuch kind of preparations, they will

be the better understood with it, than without it, and I have not now the leisure to new-mould them.

Thus then;

TAKE of the blood of an healthy young man, as much as you please, and whilst it is yet warm, add to it * twice its weight of good spirit of wine, and incorporating them well together, shut them carefully up in a convenient glass-vessel, wherein the matter must be set to digest in *balneo*, or horse-dung, for six weeks, or more: then in a glass-head and body, placed in ashes or sand, draw off with a gentle heat as much liquor, as will come over without necessitating you to impress any empyreuma upon it; the remaining matter must be taken out, and put into a strong and capacious retort, which being placed in sand, and accommodated with a large receiver carefully luted to it, the matter therein lodged must be gradually pressed with a vehement fire, which must at length be increased, till it be strong enough to give the bottom of the retort a red heat. There will first come over (after perhaps a little phlegm) spirit, either accompanied or closely followed by a copious volatile salt, fastening it self to the sides and top of the receiver; and much about the same time, there will also come over an oil or two, or more, (for I have not observed the oleaginous part to come constantly and regularly after the same manner). The receiver being taken off, all that it contains may be poured together into a convenient phial, to be therein digested for a month, if you please; or otherwise without that previous digestion, you may wash down the volatile salt adhering to the sides of the receiver, with the spirit and oil well shaken about it, and pour all together into a large glass-funnel well lined with cap-paper, first moistened with spirit of fair water, through which the spirit, and as much of the volatile salt, as it and the phlegm can dissolve, will pass first, leaving the oil behind them in the paper, which must be seasonably set aside, or else the oil also, though more slowly, will pass through the filtre. The phlegm, salt, and spirit must be rectified with a very gentle heat, so often, till the phlegm be perfectly separated, and they leave no *feces*: the oil also may be rectified two or three times from its own *caput mortuum* calcined, or else from salt of tartar, to deprive it of its muddiness. The distempers, wherein this *arcanum* or spirit of man's blood is proper, are divers, but chiefly asthmas, epilepsies, acute fevers, pleurisies, and consumptions. But to comply with my present haste, I shall advertise you in the general, as to the use of this and the other remedies to be subsequently mentioned, that for them I must refer you to the particular narratives, which I shall scarce, if you seasonably desire them, refuse you: and in the mean time, because the volatile remedies are near enough of kin to each other, I shall add to this first process (which is at the least one of the noblest of them) some observations of a more general nature, that we may both of us avoid the trouble of needless repetitions.

OBSERVATIONS.

1. I IGNORE not, that there are extant in *Burgravius*, *Beguinus*, and divers other chymical authors, very pompous and promising processes of the essence of man's blood; to which they ascribe such stupendous faculties, as I should not only wonder to find true, but admire, that they can hope the reader should believe them so. But of these preparations, some being, as that of *Burgravius* in his *Biolychnium*, very mystical and unlikely; and others, like *Beguinus* his *Q. E. sanguinis humani*, exceeding

Observations touching the manner of drawing the volatile salts and spirits of salt and blood, and other substances belonging to the animal kingdom.

* This, if I mis-remember not, was the proportion I employed in the exactest of my experiments of this kind, but it seems to be essential to the goodness of the remedy; the spirit of wine serving chiefly but to keep the blood from corrupting.

laborious, and not so clear, I have never put myself to the trouble of making them; but I shall be very forward to acknowledge their excellency, if any man shall vouchsafe me an experimental conviction of it. For though I think the preparation of blood no bad one, yet I am far from daring to affirm there cannot be a better.

2. He that intends to have any considerable quantity of this spirit and salt, must provide himself of a large proportion of blood, or else he is like to fall short of his expectation; because as full of spirits as blood is supposed to be, it yields commonly (at least the best I have hitherto met with) no less than two thirds, or more, of phlegm, besides a not despicable quantity of terrestrial and unserviceable matter.

3. It is requisite, both that the retort, wherein the dried blood is distilled, be pretty large and strong, and that the fire be very carefully and gradually administered, lest either the copious fumes break the too narrow vessels, or the matter too hastily urged boil over into the neck of the retort or the receiver; both which dangers this advertisement may help you to avoid at a cheaper rate, than I, who have not been forewarned of them but by unwelcome experience.

4. THERE is a friend of mine, an excellent chymist, whose rare cures first gave me a value for remedies made of blood, who useth (as himself assureth me) to mingle with the spirit that other liquor, drawn over at first in a head and body, and twice or thrice rectified by itself. But that liquor consisting almost totally of the spirit of wine, and the not over-grateful phlegm of the blood, though there may perhaps be passed into it some of the more fugitive particles of the volatile salt; yet they being so few as scarce discernable, this liquor seems fitter to be made a vehicle, than an associate of our spirit, and perhaps too is not in all cases the most proper vehicle, in which it may be administered: (though if it were not for the spirit of wine, I should somewhat suspect, that the phlegm, though so destitute of the more active ingredients, as to be fit to be kept separated from them, may not itself be quite devoid of specifick virtues). But my esteem of the artist I have mentioned, doth make me think it fit to acquaint you with his practice, notwithstanding that hitherto his authority be the chief thing, that recommends it to me.

5. DIVERS ways may be proposed of purifying this spirit and salt we are discoursing of, but having tried several, that which I now use is this, that follows: I put the salt, phlegm, and spirit together, in one of the highest and slenderest bodies I can get, that the phlegm might not be able to ascend easily into the head, and that the volatile salt may be the better separated. Then in a very gentle heat (I most use that of a lamp-furnace) there will ascend pure white and volatile salt, adhering to the cheeks and nose of the glass-head, which if I desire by itself, I sweep it away before the spirit begins to rise; but most commonly I suffer the distillation to proceed, and the ascending spirit to carry down part of the volatile salt into the receiver, and so I continue the same degree of heat, till there arise so weak a spirit, that it plainly begins to dissolve the volatile salt. Then shifting the receiver, I reserve the strong spirit and volatile salt by themselves, and take the succeeding weaker spirit by itself also; to which, if I please to fortify it, I add as much of the volatile salt, formerly reserved, as it is able to dissolve. In the bottom of the cucurbit or phial there will remain a phlegmatick kind of liquor, which usually contains some of the salt or spirit, and sometimes too (which is somewhat odd) some of the oleaginous part of the blood, which did not before appear to have been associated with the spirit, and to have passed through the filtre with it. This nauseous liquor may be kept by itself, till you have a sufficient quantity of it, to be worth the trouble of severing from it the nobler parts. The spirit and salt above-mentioned may be again rectified *per se*, with the like gentle heat as before, so often, till they leave behind them no fæces, nor phlegm at all. But this is requisite to be done only when, to master some stubborn disease, the medicine is to be exalted either

to its supreme, or at least to some approaching degree of purity and efficacy; for otherwise so exquisite a depuration is not always necessary.

6. As for the oleaginous part, which the fire forceth out of blood, my observations of it hitherto have so little agreed, that I dare as yet speak but hesitantly concerning it. For sometimes but one oil hath been drawn over, sometimes two: and I remember, last year, a parcel of blood, that was kept in a dung-hill for many months, yielded us a blackish and muddy oil, a purely red one, and another of pale amber colour, which would not mingle with the darker; of each of which sorts I yet reserve some by me. This difference may possibly proceed partly from the previous preparation, or unpreparedness, of the blood, and partly from the various administration of the fire employed to distil it. But for the most part we find these animal substances (if the degrees of fire be orderly administered, and the heat sufficiently intended towards the close of the distillation) to yield a double oil; the one more light and pure, which swims upon the spirit; the other more muddy, adust, and ponderous, which sinks to the bottom of it. The use of these oils hath, by reason of their fetidness, been by most authors absolutely rejected; and even those few, that do not altogether reject them, forbid their inward use, and allow them to be but externally employed. But considering, *Pyrophilus*, how much of the efficacy both of plants and animals is observed to reside in their oleaginous part, it seemed not improbable to me, that these oils might deserve a better usage, than either to be wholly thrown away, or confined to outward services; and therefore having not long since given a friend of mine some pure yellow oil of mens blood, dissolved in spirit of wine, to try upon a patient of his, sick of a hectic fever (in which disease I had seen the spirit of blood very successful) within a few days he brought me word of the unexpected recovery of his patient, to whom he administered our medicine (that I may not conceal from you that circumstance) in *Balsamus Samech*, made with spirit of vinegar instead of spirit of wine; the remaining part of this yellow mingled oil I keep yet by me, to make further trials with it. And that such oils may not be lost, I have been attempting (for I am yet upon my trials) several ways to make them serviceable. Some of them, that are of a more pure and defecated nature, I have (which is not unworthy your noting) found capable of readily uniting with spirit of wine, with which they may be allayed at pleasure: in others I have separated the finer and more volatile part, by drawing them over with a very gentle heat in a retort half full of water, which will carry over the lighter part of the oil with it into the receiver, wherein the oil will swim upon it, and may be afterwards severed from it by a separating glass, or any other convenient way; (but I fear that this method, though it finely clarifies oils, may rob them of the best part of the efficacy they may perchance derive from the latent admixture of somewhat of the volatile salt:) at the bottom of the retort there will remain a dark and thick substance, whose nature I have not yet had opportunity to inquire into. Out of some oils (drawn from unprepared materials) which would not dissolve in spirit of wine, I have, by digestion with spirit of wine, drawn much of the scent and taste; the spirit probably imbibing some of the finer parts of the oil, or else associating to itself some volatile salt, that yet lay lurking in it: for sometimes I have observed oils, after long keeping, to let fall a volatile salt undiscerned in them before. Having also sometimes mingled the heavier and lighter oils of the same body with dephlegmated spirit of wine, and in a low retort drawn over what will rise in a very gentle heat (inferiour to that of a *balneum*) I have found the spirit of wine to carry over with it so many of the more subtle and active parts of the oil, that it was more richly impregnated therewith, than you will be apt to expect. But of what use this oleaginous spirit may be in physick, I have not yet had time to consult experience; which I hope will, ere long, teach me better ways of improving the

the rejected oil, we have been speaking of, than are those almost obvious ones hitherto mentioned, wherein I am very far from acquiescing; especially since I cannot but suspect, but such active parts of such concretes would be found very capable of a great improvement, if we were as skilful to give it them.

7. THE terrestrial substance, that remains after the liquors are drawn off, if the blood have been duly prepared, affords but so inconsiderable a quantity of fixed salt, that unless the caput mortuum be exceeding copious, the alkali will hardly be worth extracting: besides, that if it could be obtained in a not despicable quantity, I should, whatever is pretended, very much doubt, whether it would be endowed with very extraordinary virtues; the violence of the fire usually depriving fixed salts of the specifick qualities of their concretes: and even in the first salt of serpents themselves, I have not discerned other than the wonted properties of alkalizate salts.

8. BECAUSE you may sometimes not have the leisure to wait six weeks for the preparation of blood, and because oftentimes the occasion of using the medicines we have been describing, may be so hasty and urgent, that unless some speedy course to relieve them be taken, before the physick can be prepared, the patients will be dead; I think it not amiss, *Pyrophilus*, to advertise you, that though without any previous preparation of blood you should immediately distil it, provided an orderly gradation of heat be carefully observed, it will yield you a reddish spirit, and (besides an oil or two) a volatile salt; which being rectified, are so little inferiour, in any properties discernible by the smell or taste, to the salt and spirit of predigested blood, that it is very probable their efficacy will emulate, though not altogether equal, that of the more laboriously prepared.

9. AND because it is difficult to get the blood of healthy men, and perhaps not safe to use that of unsound persons; and because many have a strong aversion, and some an insuperable, though groundless abhorrency, from medicines made of man's blood, I have thought it not amiss to try, whether that of some other animals prepared the same way, might not afford us as hopeful medicines. And because the blood of deer is chiefly (and perhaps not causelessly) commended by authors, we have handled it according to the foregoing process, and thereby obtained of it a spirit, and salt, and oil, whose penetrancy, and other resemblances, make us hope, that they may prove good succedanea, in the defect of those analogous remedies (drawn from human materials) which we have been treating of.

AND to this let me, *Pyrophilus*, on this occasion, annex this advertisement, that though in these papers, and what I have further written of preparations of this nature, I name not any great number of concretes, as having drawn their volatile salts and spirits, yet I have endeavoured in these discourses to give you, in the instances I insist on, so much variety of examples, that either by the processes therein set down, or by the analogy to them, you may, I suppose, be directed, with the help of a few trials, to obtain the volatile salts and spirits of most concretes, that belong to the animal kingdom, and that are capable of affording any. For by the method we prescribe, a little varied according to the exigencies of particular bodies to be distilled, we have drawn the spirits, salts, and oils of sheep's blood, eels, vipers, &c. the latter of which yield a salt and liquor, which in *Italy*, by divers learned men, is superlatively extolled against obstructions, foulness of the blood, and I know not how many diseases proceeding from these two general causes. And though I dare not deny, that divers of those praises may be well enough deserved by the remedies, to which they are ascribed; yet I am not apt to think them much superiour to the generality of volatile salts: and even the spirit and salt of sheep's blood it self did, by
their

their penetrancy of taste, and fugitiveness in gentle heats, promise little less efficacy than those others so much celebrated medicines.

10. Nor is it only by being administered itself, that one of this sulphureous and subtle kind of spirits may become a good remedy, but also by its being made a menstruum to prepare other bodies: for it will extract tinctures out of several sulphureous and resinous concretes, whose finer parts, by being associated with so piercing a vehicle, may probably gain a more intimate admission into the body, and have their virtues conveyed farther than otherwise they would reach. And a learned doctor, to whom I recommended such kind of remedies, confessed to me, that by the bare extractions of appropriated vegetables themselves, with spirit of urine, he performed no small matter. But one difficulty you may meet with in drawing the tincture of minerals, and other very compact bodies, even with good spirit of urine; (for that I account to be the cheapest of these volatile menstrooms, and the most easy to be obtained in good quantities). For we have found, but with a little heat, the more fugitive particles to ascend to the upper parts of the glass, and there fasten themselves in the form of a salt; by whose recess, the debilitated liquor was disabled from drawing the tincture so powerfully as was expected: wherefore we were reduced to make our extractions in short-necked glass-eggs or phials exquisitely stopped, (which may also be placed stooping in the sand) and when we perceived much to be lodged in the necks of the vessels, by barely inverting them, the hot liquor soon reimbibed the salt, and was fit to be placed again in sand; so that, notwithstanding this difficulty, we are able by this means, in no long time, to impregnate the spirit of urine, or of hartshorn (for I do not perfectly remember, which it was) with the tincture of flowers of sulphur, which may probably prove a noble medicine in divers affections of the lungs, since in them these volatile liquors alone have been found very effectual. And I remember, I have sometimes made a much shorter, and more odd preparation (which at any time you may command) of crude sulphur, whereby in not many hours I have, by the means of salts, brought over such a sulphureous liquor or tincture, as even in the receiver was of a red colour, as well as of a strongly sulphureous scent.

How to draw tinctures, as of sulphur, &c. with the saline spirits.

To Page 135, &c.

Where *Ens Veneris* is treated of.

BUT before I enter upon particulars, I think it will not be amiss to tell you, how this preparation first occurred to us, because by that information your happier genius may peradventure hereafter be prompted to improve this remedy, or to devise one more approaching to the nature and excellency of that, which we endeavoured, but with very imperfect success, to light on, or equal, by our *Ens Veneris*. I must then tell you, that an industrious chymist (of our acquaintance) and I, chancing to read one day together that odd treatise of *Helmont*, which he calls *Butler*; when we had attentively perused what he delivers of the nature, as well as scarce credible virtues of the *lapis Butleri* he there mentions, we fell into very serious thoughts, what might be the matter of so admirable a medicine, and the hopefullest manner of preparing that matter. And having freely proposed to one another our conjectures, and examined them by what is delivered by *Helmont*, concerning the preparation of *Butler's* stone, or some emulous remedy, we at length concurred in concluding, that either the *lapis Butleri* (as our author calls it) or at least some medicine of an approaching efficacy, might (if *Helmont* did not mis-inform us) be prepared by destroying (as far as we could by calcination) the body of copper, and then subliming it with sal armoniack.

How the author first happened upon the preparation of *Ens Veneris*.

AND because the body of *Venus* seems less locked up in good vitriol, than its metalline form, we concluded, that it was best to calcine rather the vitriol, than the copper it self; and, having freed the colcothar from its separable salts, so to force it up with sal armoniack. But the person I discoursed with, seeming somewhat diffident of this process, by his unwillingness to attempt it, I desired, and easily persuaded him, at least to put himself to the trouble of trying it with the requisites to the work, which I undertook to provide, being at that time unable to prosecute it my self, for want of a fit furnace in the place where I then chanced to lodge. And though at first we did not hit upon the best and most compendious way, yet during the sublimation, he being suddenly surprized, as both himself and his domesticks two days after told me, with a fit of sickness, attended with very horrid and seemingly pestilential symptoms, was reduced to take some of this medicine out of the vessels before the due time, and upon the use of it found, as he told me, an almost immediate cessation of those dreadful symptoms, but not of the paleness they had produced. This first prosperous experiment emboldened us to give our remedy the title of *Primum Ens Veneris*, which, for brevity's sake, is wont to be called *Ens Veneris*; though I am far from thinking, that it is the admirable medicine, to which *Helmont* gives that name, at least, if his *Ens Veneris* did really deserve half the praises by him ascribed to it. But such as ours is, I shall now (as time and my yet incomplete trials will permit) acquaint you with that process of it, which (among some others) we are most wont to employ, as the most easy, simple, and genuine.

The process
used by the
author for
the making
of *Ens
Veneris*.

TAKE then of the best Hungarian, or, if you cannot procure that, of the best Dantzick, or other good venereal vitriol, what quantity you please; calcine it in a strong fire, till it be of a dark red; dulcify it by such frequent affusions of hot water, that at length the water, that hath passed through it, appear full as tasteless, as when it was poured on it. Let this, thus exquisitely dulcified colcothar, when it is thoroughly dry, be very diligently ground with about an equal weight of good sal armoniack, and let this mixture be put into a glass retort, and either in as strong a heat as can conveniently be given in sand, or else in a naked fire, force up as much of it as you can to the top of the neck of the retort; and this sublimation being ended, out of the broken retort (laying the caput mortuum aside) take all the sublimate, and grind it well again, that if in any part the sal armoniack appear sublimed by it self, it may be re-incorporated with the colcothar; resublime this mixture *per se* in a glass-retort as before, and, if you please, you may once more elevate this second sublimate, but we have not found that always needful. And for the better understanding of this process, be pleased to take notice of the following particulars.

Divers particular
an-
madversions
concerning
the prepara-
tions.

FIRST, We have always preferred such vitriol as abounds with copper, before our common English vitriol, about the making of which, those that keep the copperas-work at *Deptford* are wont, as themselves have upon the place informed me, to use good store of iron to increase the quantity of their vitriol.

SECONDLY, If you be unwilling to lose the phlegm, spirit, and oil of that vitriol, with which you design to make *Ens Veneris*, you may distil them away in an earthen retort, or one of glass well coated. But though it be well known, that the distillation of oil of vitriol requires a very intense and lasting fire, (so that unless you have need of the liquors, the best way will be without any ceremony to calcine the vitriol in a naked fire and open) yet afterwards it will be for the most part requisite, farther to calcine the caput mortuum in an open vessel. For you must take notice, that unless the vitriol be very thoroughly calcined, it will be very troublesome for you to dulcify it; and sometimes we have observed, that the caput mortuum which looked red,
and

and seemed indifferently well calcined, hath been, almost like crude vitriol, dissolved in the fair water, which was poured on it, to dulcify it. The weight of the calx, in reference to the vitriol of which it was made, we cannot easily determine; but we have sometimes found it necessary to reduce the vitriol to less, perhaps much less than half its weight, to make fit for dulcification.

THIRDLY, The water, that hath been poured off the first and second time, to edulcorate the calcined vitriol, may be filtrated and steamed away, till it come almost to the consistence of a syrup or honey, and then may be put into a cold place to shoot; for after this manner we have sometimes had many very regularly figured crystals or grains of salt: I say sometimes, because sometimes also you may find it necessary to abstract all the water, to obtain the whitish salt of vitriol, which we have known used as a good vomit, and which *Angelus Sala*, none of the least sober of the chymical writers, doth highly extol as an excellent emetick, in his *Ternary of vomitive remedies*, where he discourseth at large of the virtues of it, and the way of administering it. And of this salt, as chymists are pleased to call it, we have had out of calcined copperas a very great quantity, and have sometimes observed it to have been almost as deeply coloured, as the vitriol it self was before calcination.

FOURTHLY, We several times tried to sublime dulcified colcothar with sal armoniack, in retorts and urinals placed in sand; but whether by reason of the fixedness of the colcothar, or because the furnace we were fain to use, though no very bad one, was none of the best, we never could that way obtain any considerable quantity of the desired sublimate, and that, which did ascend, was but of a faint colour: wherefore, unless you have an extraordinary good sand-furnace, if you will make use of glass-vessels, which is the cleanest way, you will find it expedient to sublime your colcothar in coated retorts with an open fire, except you have the dexterity to sublime in a naked fire with glass retorts uncoated, which we have divers times seen performed by heating the bottom of the retort by degrees, and then placing it upon embers, with coals round about it, but to be kindled at a distance from it: for if this course be watchfully followed, the retort will be so well nealed, before it be reduced to endure any intense degree of heat, that after a while you may safely lay thoroughly kindled coals, not only round about it, but upon the top of it, (which needs not to be done till towards the end of the operation) and thereby drive most of the sublimate into one lump, and into the neck of the retort. And by this way you may sublime any furnace upon a bare hearth; but if you desire to give a more intense heat, you may lay first some warm ashes in an ordinary iron pot, and having with them, and a few small coals well kindled, nealed your retort, you may afterwards prosecute the sublimation in the same pot, which being once thoroughly heated it self by the fire, will afterwards considerably increase the heat of it.

FIFTHLY, Though it be most commonly requisite to resublime the sublimate, that comes the first time up, that the salt and colcothar may be more exquisitely mixed, yet as far as we can guess by some trials, it will not be expedient to resublime it above once or (at most) twice. For in those trials we have found the *Ens Veneris* oftner resublimed of a paler colour, than that which was resublimed but once. And (*NB*) perhaps, by farther sublimations, the salt, instead of being more intimately united with the colcothar, may be almost totally severed from it, according to what we elsewhere in other cases declare.

SIXTHLY, Of these sublimates, that, which hath the highest colour, seems to be the best, as being most enriched with the colcothar, from whence the redness proceeds. But at the first sublimation I have often observed a pretty part of the sal armoniack to come up first white by itself, especially if it had not been very diligently

mixed with the colcothar. But at the second sublimation the ingredients (which we have sometimes almost totally forced up without leaving a caput mortuum in the bottom of the retort) will be more accurately mixed, and the sublimate will appear yellow, and perhaps reddish, of which sort we have sometimes had, when the operation hath been carefully managed.

SEVENTHLY, How great a proportion of the ingredients committed to sublimation will arise in the form of *Ens Veneris*, we dare not precisely define; but sublimate amounting to the fourth part of the whole mixture, you will scarce, if you work skilfully, fail of.

EIGHTHLY, We sometimes made a sublimate of equal parts of pure sal armoniack and salt of tartar, both of them very thoroughly dried, (for else they will be apt to yield rather a spirit than a sublimate) well ground together, and so sublimed. And with this sublimate instead of simple sal armoniac we intended to make *Ens Veneris*, but by some intervening accidents and avocations we were not able to perfect the experiment, of which we nevertheless think it fit to give you this hint, because of the great efficacy, which an excellent physician of my acquaintance, to whom I gave some of it, assures me he has found in it against obstructions, and some distempers, that are wont to spring from them.

NINTHLY, When you are about to make your first sublimate, you may, if you please, lute to the retort, whereinto you put the ingredients, a small receiver to catch the liquor that oftentimes comes over. For that liquor, though you will very seldom get much of it, yet it may be worth your preserving, by reason of the volatile and urinous salt wherewith it will sometimes so abound, that it may pass for a weak spirit of sal armoniack.

TENTHLY, The caput mortuum, that remains after the first sublimation, may be put into a clean glass, and set in a cellar, where it will run *per deliquium*, into a thick and high coloured liquor, very richly impregnated (as we elsewhere manifest on another occasion) with the somewhat opened body of copper; from whence, if half those praises be true, which even the best chymists are pleased to give to copper, it may be very well concluded to have derived no small virtues against ulcers, and divers affections, which we are not here to insist on.

ELEVENTHLY, We have sometimes doubted whether or no our *Ens Veneris* did really contain any thing of cupreous or colcotharine in it, partly because of the fixedness or sluggishness of colcothar, and of the copper therein contained; and partly because, that if sal armoniack be two or three times sublimed by it self, its flowers frequently enough will ascend yellow, like the paler sort of *Ens Veneris*. But first, that sal armoniac is capable of carrying up even fixed and sluggish bodies, seemed probable to us, partly upon our incorporating and subliming it with finely powdered corals, (from which, though but very little of it ascended, yet some of that little was no less red, than the corals themselves before their being beaten) and partly upon our subliming it from copper, both crude and calcined, since of either of those bodies it carried up a little with it, as appeared by the blue colour of some parts of the sublimate.

AND secondly, that the reddishness of our *Ens Veneris* proceeded partly, if not altogether, from the colcothar, seemed probable to us, not only by the taste, and some other properties of it, but also by this, that having knowingly committed the first sublimate to a fire too weak to resublime it; and having after some hours taken the vessel out of the sand, we found that the fire, which we supposed was not strong enough to carry up the whole matter, had raised the sal armoniack to the upper part of the urinal in flowers, that were either white or but pale yellow; whereas the
remaining

remaining part of the mixture, that lay in good quantity in the bottom of the vessel, was of a deep red, and a fragment of it of about the bigness of a large pea, being cast upon glowing coals, and nimbly blown with a pair of bellows, coloured the flame with somewhat greenish blue, like that, but more faint, which we elsewhere have observed to proceed from the well-opened body of copper.

But those trials, I confess, would rather increase my doubts than lessen them, because in our *Ens Veneris* the colour is not blue, but reddish; if I did not consider, that colcothar is a body, that consists of some other matter besides common copper, (as it is also far more difficult to reduce, though but in part, into a metal, than is vulgar calcined copper) and consequently when corpuscles of differing natures are by the sal armoniack elevated together, that, which is not metalline, may, with the assistance of the fire's operation, alter the nature of what it is, and thereby produce a colour differing from blue. But to dispatch whatever further trials shall inform us, touching this question, whether or no any true and reducible copper do make an ingredient in our *Ens Veneris*, yet there being in colcothar other parts as well as those, that by fusion you may reduce into a pure metal, and our remedy seeming by its somniferous property to partake of them, it will not be necessary to the giving our medicine a right to the appellation I commonly choose of *Flores Colcotharis*, that in it there is something of the colcothar carried up, though possibly the quantity be but small, and not all reducible into a metalline form. But perhaps the question is not worth a longer debate, it being sufficient to excuse the name, and recommend the thing to such a person as you, that colcothar is employed in the making of it, and that the thing prepared is a noble medicine, and hath some of the great virtues ascribed to vitriol; whether that mineral be an ingredient of it, or no.

THE dose of *Ens Veneris* may be very much varied: to little children we give sometimes one, sometimes two, and sometimes three grains for many nights together, as we find them able, without inconvenience, to bear the operation. To persons of ripe years we commonly administer four, five or six grains at a time. But one, to whom we have given quantities of it to lie by him, tells us, that he hath taken to above thirty grains at once without any inconvenience. We are wont to give it in two or three spoonfuls of sack, or other wine, if the constitution of the patient, or the nature of the disease do not forbid it; and, in such cases, we give it in any cordial liquor, that is temperate, or any other convenient vehicle.

To children it may be given in beer, or ale, or clear posset-drink, but not in milk. If the patient hath supped at a seasonable hour, we commonly administer it, when he is going to sleep. It works for the most part by sweat and a little by urine, but more by sweat at the beginning, than after the body is used to it; yet to some bodies it proves so sudorifick, that two grains, or less of it, have often made me sweat. That it hath once proved emetick, I have heard, but never observed it my self to provoke vomits.

As for the medical use of *Ens Veneris*, divers great physicians will perhaps think it were not despicable, though it were no other than oftentimes to prove a safe and moderately somniferous medicine in fevers, without having any thing in it of opium, whose narcorick power they find as difficult to correct, as oftentimes proves dangerous, when being not well corrected, it is administered without very great circumspection.

But—*****

The dose
and use of
Ens Veneris.

To the 141, 142, 143, 144th Pages.

[Finding among my loose notes, together with those, that do immediately concern the preparations of sulphur and hartshorn (delivered in these pages) some other particulars, that may also serve, either to afford some light to readers less skilled in chymistry, or contribute somewhat or other towards the relief of some patients, I am content to let those papers go together, as I long since addressed them to a friend.]

Of hartshorn.

HARTSHORN, *Pyrophilus*, is a heteroclit body in nature, which hath but few resemblers in the universe; for it grows to a considerable bulk like a vegetable, and is (unlike most other horns of animals) at certain set periods of time, deciduous; and though it be of a bony substance, yet that middle part of it which differs from the rest in colour, does (at least in grown horns) much more resemble the pith of some plants than the marrow of bones: and yet this plant-animal (if I may so call it) does, when skilfully exposed to the fire, afford the same differing substances, with the blood, flesh, and other part of animals. It is no wonder therefore, if physicians and chymists have hoped to find extraordinary virtues in so extraordinary a subject, of which we shall pass by the usual preparations, as not so pertinent to our present design, insinuating only in the general, that though even the more vulgar preparations, as well as that which physicians have been pleased to call philosophical, afford us medicines not despicable; yet these are much inferior to those remedies wherewith dexterous distillations are capable of presenting us. And certainly if we allow of the chymical theory, (whose truth in these papers I question not) harts-horn being generally acknowledged to be endued with properties very friendly to our nature, and even those ways of preparing it, wherein the nobler and more active parts are not truly freed from those cumbersome ones that fetter him, and hinder them to display their powerful energies, proving yet oftentimes not unavailable: the spirit and salt of harts-horn would be in more request, were not men deterred from making trials of it, partly by the over-apprehended unpleasantness of the smell, and partly by the difficulties commonly met with in its distillation; the latter of which determents hath so frightened even chymists from distilling this cordial substance, that we have very rarely seen any, either spirit or salt of hartshorn, save what our selves have been induced to prepare.

Three ways of distilling hartshorn.

THERE are three ways proposed by the authors I have met with, to distil hartshorn: the one in coated glass retorts; the other in earthen ones; and the third in Glauber's second philosophical furnace.

IN the first of these ways, some very skilful distillers, that have often practised it, have so complained of their frequent breaking their vessels by the copiousness, and impetuosity of the fumes, that rush out of the matter, when it once begins to be prest with a considerable heat, that I confess to you ingenuously, *Pyrophilus*, they have hitherto frightened me from making trial of that way; though I see no very great reason why, by a slow and regular gradation of the fire, the mischances incident to this way of distillation may not (at least most commonly) be avoided.

To distil the matter we discourse of in earthen retorts, is a safer way than the former, if the earth be close and good, and have been sufficiently baked; as we find in the right *Hessian* retorts, wherein we have known the operation proceed very prosperously, though a considerable quantity of the matter hath been distilled at once; but the retorts made of earth, that is spongy, or any other ways unfit, or in whose baking fuel hath been spared, are commonly (as experience hath informed us) improper for this service, wherein they are easily broken: besides that it is much to be feared, that all retorts made of earth, except it be extraordinarily compact and baked, are apt to imbibe the more subtile and more penetrant parts of hartshorn,

and other volatile substances distilled in them; which we have observed in some, wherein the matter hath transudated quite through the substance of the retort, and been manifestly discernable on the outside of it.

THE third way of distilling harts-horn is performed by the instrument described by *Glauber*, in his second philosophical furnace: but neither is this way without its inconveniencies: for besides that, if the earth whereof the vessel to be employed is made, be not very good and well baked earth, it will be apt to crack, in so violent a fire, as is requisite in this way of distillation, or else it will imbibe part of the finest spirit it should transmit into the receiver: and besides that it is difficult to work long this way, without letting some of the active part of the spirit escape between the wide orifice of the retort and the cover: besides these inconveniencies, I say, it is to be feared, that the matter being to be cast immediately into the vessel, made red-hot before-hand, it will receive a stronger empyreuma, or impression of the fire, than it would do in the ordinary way of distillation; wherein the fire being orderly and successively increased, much of the spirit and salt comes over into the receiver, before that last degree of fire is administered; which is requisite chiefly to force over the more sluggish and heavy oil, which therefore (to speak congruously to the most received theory of distillation) favours much more of the fire, and is grown almost infamous for its adustion.

BUT notwithstanding these inconveniencies, *Pyrophilus*, we have found these retorts of *Glauber's* not unserviceable, when we have had occasion to distil considerable quantities of such materials, as were not so precious, as to make the loss of a part of what they were to afford us, considerable.

AND this advertisement may take place, especially if you take along with you what we have declared, touching the ways we substitute, to avoid, as much as may be, the newly objected inconveniencies. But having in other papers taken notice particularly enough of the ways we mean, I shall forbear to mention them in this place, though one of them may easily be made applicable, as experience hath assured us, even to ordinary retorts: for it is not difficult to apply *these*, the perforated receivers, which being almost of the shape of pears, open at both ends, by holes of about two or three inches diameter (according to the capacity of the vessel) may be with great facility taken asunder and made clean; and may, by the convenient insertion of their extremities into one another, be easily luted together (in a level) two or three, or as many of them as necessity shall require: and then, provided there be applied to the remoter extremity of the last of them, some convenient vessel open but at one end, the receivers will very seldom break: the fumes that come over too copiously to be contained in one of them, passing freely thence into the second or the third (for we very rarely exceed three in all) which will be manifestly cool, and so, speedily turn into liquor, the fumes it receives; whilst the first recipient is perhaps hotter than the hand can endure: but of these mechanical contrivances elsewhere.

Now whereas *Glauber* prescribes to mingle with the distilled liquors of hartshorn rectified spirit of wine, to wash out the volatile salt, and directs the distilling again of both those spirits (of wine and hartshorn) together; his method of proceeding may be justly questioned. For first, dephlegmed spirit of wine will not so readily, in the way he supposeth, dissolve the volatile salt of hartshorn; and next, the spirit this way drawn is not a simple spirit of hartshorn, but a compound liquor of the spirit of hartshorn, and that of wine; the latter of which may possibly, in divers cases, rather impair than improve the virtue of the former. For spirit of hartshorn, by reason of its opening and resolving, as well as cordial virtues, is safely and successfully given in fevers, wherein it is not observed to inflame the blood; whereas spirit of wine in such cases.

Animadversions on some preparations of hartshorn of *Glauber* and *Hartman*.

Tract.
Chym.
p. 190.

cases is counted dangerous. And this brings into my thoughts a very questionable preparation of the experienced and ingenious *Hartman*, who much extols for the worms in the stomach, spirit of hartshorn in general, but especially that which he is pleased to call *Essensificated*, (that is, as himself expounds it) with which its own fixed salt, extracted with some convenient water, and its volatile duly depurated, have been dissolved and united. For first, the fixed salt of hartshorn hath been perhaps never yet prepared by any man: and if hartshorn doth yield a fixed salt (as I dare not absolutely deny, but that out of many pounds a few grains may be extracted) it may well be doubted, whether that salt be endowed with specific virtues: and next, the spirit of hartshorn, if it be well dephlegmed, will not (for aught I could ever find) dissolve its own salt, unless assisted by the external warmth of the ambient air. Inasmuch that I usually keep the spirit and salt in the same phial, where they remain unmixed; and the spirit, that will dissolve any of its own salt, I account not sufficiently dephlegmed, but to have yet an aqueous alloy, whereby the salt is imbibed. And I remember, that having once exquisitely rectified some spirit of hartshorn, and closed it up in a phial, after divers months it let fall a considerable quantity of volatile salt; so far was it from being able, without the help of some peculiar way, to have dissolved more, had I cast more into it. I deny not, that the spirit of hartshorn may, by the mediation of heat, be brought to take in some of the salt of the same body: but of what use this violent impregnation of the liquor can be, unless it be quickly administered, I do not yet understand; having often seen the spirit let fall again in the cold, the volatile salt it had dissolved by the assistance of heat.

A fourth
way of pre-
paration
of harts-
horn, used
by the
author.

AND having thus, *Pyrophilus*, laid before you the difficulties we have met with, in the above-mentioned ways of making of spirit of hartshorn, proposed by authors, (neither of which we would yet have you altogether reject) I must acquaint you, with our having attempted a fourth way, which when the matter to be distilled is not very much, I chuse rather to practise than any of the other, as hitherto seeming more safe and free from inconveniences. Take then (for instance) two pounds of hartshorn broken on an anvil into pieces, each of about the bigness of one's finger, (for if it be rasped, there is danger, that it should emit its fumes too plentifully at once) and put it into a strong glass-retort uncoated, big enough to contain at least twice as much matter: set this in sand, and fit to it a pretty large and strong (either single or double) receiver; then give a slow fire for three, four, or six hours, to send away first the phlegm, and more fugitive parts of the spirit. Then increasing the fire, but warily, and gradually for divers hours, drive over the spirit (which is wont to drop down somewhat tinged) and the more volatile parts of the salt; and at length intend your fire till the bottom of the retort be glowing hot, and heap also at last quick coals upon the sand round about the retort, to give, as it were, a fire of suppression, and so force over the more sluggish remaining parts of the salt, and with it the oil: all which, are to be afterwards proceeded with, according to the directions given concerning the spirit, salt, and oil of man's blood; which having been sufficiently insisted on before, will not (I suppose) need to be repeated now. Only it may not be impertinent to advertise you, 1. That we have more than once had the bottom of the retort melted, yet not broken, the melted glass being supported by the substrated sand. 2. That sometimes in filtration, some of the thinner parts of the oil have unperceivedly passed through the paper with the spirit and salt, and have not been discovered, but by rectification; wherein I have almost admired to see the oil, with a gentle heat of a lamp, ascend to the top of a very tall head and body: touching which circumstance it may yet be farther inquired, whether it proceed barely from the volatileness of the oil itself, or also from its being carried up by the salt and spirit, wherewith it was associated. 3. That by

by this way of distillation, we usually have out of a pound of hartshorn between four and five ounces (seldom or never so little as four, and often nearer five) of volatile salt, spirit, oil, and phlegm; (of the last of which, if the hartshorn be not recent, there will be no great quantity) and when we distilled two pound of the matter at a time, we found the operation to succeed altogether as well, and to yield us a fully proportionable quantity of liquor.

THE virtues of the spirit and salt of hartshorn, which differ not much in dose, or efficacy, are probably very great in divers distempers, wherein we have yet made no trial of them. For they are considerable in resisting putrefaction, comforting nature, opening obstructions, mortifying the acidities it meets with in the blood; and, by rendering that volatile, promoting its circulation, we have known considerable effects of it in fevers, pleurisy, obstructions of the mesentery, and spleen; and chiefly (which perhaps you will think strange) in coughs and distempers of the brain, and nervous parts: in so much that I have, by God's blessing, sometimes stopped very violent (but not inveterate coughs) with this medicine in a few hours. And prescribing it to one, who was almost daily assaulted with epileptical fits, a few doses of it did, in a pretty while at first, make his fits come but seldom, and after, not at all: but whether he be perfectly cured, not having heard of him of late, nor having had opportunity to make farther trial of the medicine in that disease, I am not certain. We prescribed it likewise, not long since, to a person, who had long lain both distracted, and almost bedrid, and was in a short time strangely relieved by the use of it, though not perfectly cured, (perhaps, because the patient took but little of the medicine, we being, then, not well stored with it) and on some, that have been by fevers rendered stupid, it hath had very eminent operations. But for a farther account of its virtues, I must refer you to the particular narratives I may, when we meet, give you by word of mouth: and till then, it may suffice to tell you, that it works chiefly by sweat (and somewhat by urine) without being observed to leave behind it such heat as divers sudorifics are wont to do: only there must be care not to administer it, when the *primæ viæ* and passages are too much stuffed and choaked up by gross humours, left by agitating the blood, and putting it into a nimble motion, it occasion greater obstructions. The dose is from five drops, or grains, to a drachm (ten or fifteen drops are wont to make me sweat) in wine, *carduus benedictus* water, or any vehicle appropriated to the disease; only taking care, that nothing acid be administered with it, because acid and sulphureous salts mortify, and disarm one another. *Hartman* commends it against the worms of the stomach, against which it may very probably be available, by reason of its penetrant and saline nature, and its enmity to putrefaction. *Glauber* writes, that the oil rectified from salt of tartar cures quartans, and inward wounds, and cures the pains produced by falls, convulsions, &c. being administered from six to twenty drops to a patient placed in his bed to sweat after it: but of this my experience will not enable me to say any thing. And I fear, *Pyrophilus*, that I have already too long entertained you about hartshorn: and yet I fear too, that you expect that, before I forsake this subject, I should say something to you concerning a much controverted particular relating thereunto. The inquiry is, whether or no, when it is distilled, the salt dispose itself, in the receiver, into the figures of hartshorn: the affirmative is maintained by many chymists, and a friend of mine, who is very severe, and not at all credulous, having assured me, that he himself had observed the inside of his receiver over-laid with such figures or horns, I dare not deny, but that accidentally the particles of the volatile salt may sometimes represent as well the shape of hartshorns, as of divers other things. But for our parts, having several ways, and not unfrequently distilled that matter, we could never see the pretended saline hartshorns, so clearly as we thought we

The use and effects of the spirit of salt of hartshorn, and the dose of it.

Q: Whether in the distillation of hartshorn, the salt dispose it self into the figure of the horn.

saw

saw cause to esteem, that those who affirmed they constantly saw them so distinctly, looked through the spectacles of prepossessed imagination: not to mention, that it is the usual method of nature in salts to make the bigger concretions of the same figures with the smaller grains, as we observe in nitre, roch-allum, &c. And the grains of the salt of hartshorn, though I have attentively enough considered their shapes, I remember not ever to have observed of a figure like that of the horns they came from: but it is the nature of volatile salts to fasten themselves to the receiver in various figures, according as the degree of fire, that urges them up, and other concurrent circumstances, do chance to exact; and consonantly hereunto, we have often observed the volatile salt of the same hartshorn to be very variously figured in the same receiver. And I remember, that, not long since, subliming some volatile salt of urine, it adhered to the upper part of the vessel in figures, much liker hartshorns, than ever I had seen their volatile salt make up: so that, unless we will merrily say, that the man, whose urine was distilled, had horns given him by his wife, we must acknowledge, that nature seems to give herself liberty to play in the configuration of volatile salts, and that casualties have no unusual influence on them; or, to speak more properly, that the various degrees of fire, the differing copiousness of the fumes, and many other intervening accidents, do keep those configurations from being constantly regular. And I remember, that, a while since, filtering through cap-paper a tincture of glass of antimony, made with spirit of vinegar and spirit of wine, almost according to *Basilus*; the matter, which remained in the paper (which was placed in a glass-funnel, and was of the same shape) did of it self, when it began to grow dry, cleave into the figures of trees, whose trunks, greater boughs, and smaller branches, were, both for their shape and proportion, as lively represented as if they had been drawn by the curious pencil of some skilful painter: which paper I shewed to some persons, that beheld it not without wonder, and, for aught I know, I am yet able to shew it you. Nor is this the only instance I could give you, if need were, if I had not trifled too long already to manifest at present, that now and then chance may make nature seem to emulate art.

That bucks-horns may be substituted for stags-horns.

BUT as long as I have dwelt, *Pyrophilus*, on this subject, before I pass to another, I must not forget to advertise you, that in case stags-horns cannot be procured for the preparation of the above-mentioned remedies, you may without much disadvantage substitute bucks-horns in their stead: for almost all the trials we have had opportunity to make of the medicines we have been lately discoursing of, have been made with remedies, whereto bucks-horns afforded materials.

How to keep the spirit and salt of hartshorn.

I HAD almost forgot, *Pyrophilus*, to tell you, that to keep the rectified spirit of hartshorn, blood, or the like, is more uneasy, than any thing but trial would make one think; and yet to keep the volatile salt is more difficult than to preserve the spirit: for more than once, when I have kept these fugitive animal salts by themselves, they have penetrated the corks, and scarce left me in the well stopped glasses any foot-steps of their having been there, and therefore those chymists, that are not strangers to these salts, have taken much pains to no great purpose, to keep them from avolation: some of the recentest and ingeniousest are wont, that they may moderate their uncurbed wildness, to pour on them as much of some such acid spirit, as that of salt of vitriol, &c. as will produce any manifest conflict with the volatile salt; never considering, that as this course doth indeed divest them of their fugacity, so it doth in effect divest them of a great part of their nature, and consequently of their peculiar virtues. For I have elsewhere shewn, that the saline corpuscles, obtainable by the fire from urine, being united with a sufficient proportion of spirit of salt, will cease to be what they were, and with the saline parts of the acid liquor, will make up a kind of

of *sal armoniack*. But it is easier for me in this our case to shew, that another man's expedient is not good, than to substitute a good one; especially in this place, where for some reasons I must not set down the way, that I the best approve of: only I shall tell you, that my way long was (nor do I yet despise it) to preserve volatile salts in their own rectified spirit, which swimming over them, kept them from the immediate contact of the air, and preserved them so well, that by this means I have secured even small parcels of the fugitive salt of human blood for many years.

[*BUT since the spirit and salt even of this sort of horns will not, I fear, be found so easy for every man, especially, if he be a novice in chymistry, to procure in any considerable quantity; and since the declared intent of my communicating to the reader my observations about these spirits of hartshorn, blood, &c. was to furnish him with such chymical remedies, that men may by their easiness and cheapness be invited to provide them, for the use of the poor; I presume it will not be improper to present him with a succedaneum or two, that may be easily enough obtained from sal-armoniack, though these preparations have such connexion with divers other passages, wherewith they were written to the person I here call Pyrophilus, that, to avoid the too much dismembring those papers, and to make these processes the better understood, I must content my self to leave out those particulars, that can best be spared; hoping, that the rest will be easily excused, at least by those, who know, how much some chymists themselves have been deluded in their trials of the divulged processes, divers of which are either false or very uncertain, and others, though they should succeed, would give but a sophistical spirit, much of the obtained liquor coming from the distillable concretes, that must, according to such processes, be mingled with the sal-armoniack, of which I could easily give instances, even out of modern and applauded writers.*]

THE spirit of *sal armoniack*, *Pyrophilus*, hath such wonders ascribed to it by chymists, that, if I should conclude these papers touching spirits of an urinous nature, without saying something to you of that, you might think I had left the considerablest of them unmentioned; but as I the rather acquaint you with the little I know of it, because, though I have met with divers authors, that extol it, I have scarce met with any, that teaches intelligibly, and candidly, how to prepare it, which perhaps most of them did not know themselves; so I hope you will exact an accurate account of it the less rigidly, because I can present to you but little on that subject, besides the few observations, wherewith my own curiosity has supplied me; having scarce ever (to my knowledge) seen any spirit of *sal armoniack*, save what my own furnaces have afforded me. And therefore without presuming to set down solemn processes about a subject, wherein I have found a small variation of circumstances hinder the operations made on it from producing uniform effects, I shall content myself to give you as true an information, as my memory will afford me, of a few of my proceedings with this nice salt, and the successes of them: only premising, in a word, that by *sal armoniack* I here mean the factitious and venal, consisting of urine, foot, and sea-salt.

Of the spirit of *sal armoniack*, and divers attempts and ways of preparing it.

AND first, according to the way proposed by *Glauber* (in the second part of his philosophical furnaces) we distilled it out of an open retort (with a cover to clap on and take off, as occasion requires) with a mixture of *lapis calaminaris*; and once we, that way, obtained a quantity of liquor, which seemed exceeding strong: but before we could make any trials with it, the phial that contained it having been accidentally broken, we lost the opportunity of satisfying ourselves of the efficacy of it. And having not long since attempted to make such a spirit the same way, there came over indeed a liquor, which seemed to be the spirit of *sal armoniack*; but when we came

to rectify it in a gentle heat, the greater part of it, to our wonder, coagulated in the retort, whereinto it was put to be distilled, into a perfect sal armoniack, (a pretty quantity of which I keep by me) and thereby betrayed the above mentioned liquor, to have been little else than the sal armoniack itself, forced over by the violence of the fire, without having suffered any separation of its ingredients. Nor is it by us alone, that the process set down by *Glauber* hath been unprosperously attempted; and yet perhaps it might have constantly enough succeeded with him, and the difference of the *lapis calaminaris* (in which we have observed much disparity, according to the places it comes from) may have produced the complained of variety of successes.

WE also attempted to distil a spirit from sal armoniack (to pretermitt divers other trials) by mixing it with equal parts of salt of tartar; but in this experiment we met with variety of success: for having exquisitely incorporated the two salts by the help of a little fair water, we have divers times had the upper part of the receiver (carefully luted on to a somewhat large retort) all candied over on the inside with volatile salts of several shapes; and the liquor afterwards forced over hath sometimes remained long enough in the form of a very subtile and penetrant spirit; and sometimes again it hath in the very receiver almost totally coagulated it self into a lump of crystalline salt: and when we had mixt the salt of tartar, and sal armoniack, without any water or other moisture at all, our successes have been very like those above mentioned. Upon this occasion I dare not omit acquainting you with an experiment, which yet I learnt not upon this occasion. Take of pure salt of tartar, and of good sal armoniack, equal parts (let them be both very dry, or else you may lose your labour) and grind them very accurately together, though you be deterred from continuing that toil, by a very subtile and fetid urinous steam, wont to exhale from the mixture: these salts being thus exquisitely incorporated, you must put them into a large glass retort, to which you may fit a receiver to catch a fetid liquor, that sometimes we have observed to come over. Then administering by degrees a very strong fire, the top and neck of the retort will be lined with a pure white sublimate, which seems to partake as well (though nothing near so much) of the salt of tartar, as of the sal armoniack and of its qualities, and yet to differ from either. And though this sublimate be far enough from being the true volatile salt of tartar, so highly extolled by *Paracelsus* and *Helmont*; yet it is no ignoble medicine in obstructions, and some other distempers: and I remember one of the most expert chymists I know, having made trial of some I presented him, told me he found such effects of it, as made him divers times very pressing and solicitous for more. The fetid liquor, that will come over, we have found sometimes to be very little, and at other times much more copious, without being able to discern clearly, whence the disparity proceeded; and the caput mortuum remaining in the retort, by solution, filtration, and coagulation, affords a pure salt of greater diuretical efficacy, than almost any I have hitherto met withal. Another way, by which we attempted to attain a spirit of sal armoniack; was, by accurately mixing two parts of it with three or four of quick-lime, whose virtue had not been impaired, by being exposed to the air. This mixture being distilled in a retort, placed in sand, with a strong fire afforded us (together with some dry sublimate in the neck of the retort, and, as I remember, a little volatile salt in the receiver) a very strong and yellowish spirit, so exceedingly penetrant, and stinking, that it was not easy to hold one's nose to the open mouth of the phial, wherein it was kept, without danger of being struck down, or for a while disabled to take breath, by the plenty and violence of the exhaling spirits. But the liquor forced over by this method, though exceeding vigorous as to its qualities, was inconsiderable as

to its quantity; and therefore we now chuse to vary a little this way of proceeding, and let the quick-lime lie abroad in the open air (but protected from all other moisture, except that of the air) for divers days: in which time the imbibed humidity of the ambient air would in some degrees flake it, and make it somewhat brittler than it was before: and the lime thus prepared, being mingled with salt armoniack, and distilled in all circumstances after the former manner, afforded us a liquor so copious, and yet so strong, that we hitherto acquiesce in this way of distilling this wild salt, as the best we have yet met with. But note, that we used, towards the latter end, to increase the fire to that degree, by heaping up coals on the upper part of the retort, that the mixture in the retort hath been brought to flow. Note also, that though even the spirit thus drawn persevered long in the form of a liquor, yet yesterday coming to look upon a phial of it, which we reserved, to try what effect time would have on it, we found, that about a fourth or fifth part of it had spontaneously coagulated it self into exactly figured grains of a crystalline salt, the liquor swimming about it; retaining, nevertheless, a very strange subtlety: which observation, concurring with divers others, makes me apt to doubt, whether or no this so celebrated spirit of salt armoniack be really much, if at all, other than the resolved salt of urine, and foot, of which that body consists, somewhat subtiliated by the fire, and freed from the clogging society of the sea-salt, to which they were formerly associated and united; though I confess it seemeth not improbable, by the great energy, which may be observed in this spirit, when it is dextrously drawn, that the entire concrete, and the quick-lime, may afford it something, that it could not receive from either of the ingredients, whence the mixture did result, as we see in aqua regis, which dissolves crude gold, though neither the salt armoniack, nor the petre, nor the vitriol alone affords, by the usual ways, spirit capable of producing that effect. The great virtues, and uses of salt armoniack, especially in physick, I cannot now stay to treat of, but you will find them largely enough set down by *Glauber*; whose encomiums nevertheless must not be all adopted by me, who in this place mention the spirit of sal armoniack but as a medicine, that is near of kin, and may serve for a succedaneum to the spirits of hartshorn, urine, blood, &c.

BUT although the last mentioned way, *Pyrophilus*, be the least imperfect one we have hitherto met with, of distilling salt armoniack; yet because you may sometimes need a spirituous liquor impregnated with the activest parts of that noble concrete, when you want either retorts to distil in, or furnaces capable of giving strong fires, I dare not omit to inform you, that we have sometimes drawn over such a liquor of salt armoniack after the following manner: Dissolve pure salt armoniack in a small quantity of fair water; then in a cucurbit put such a quantity of strong quick-lime powdered as may fill up a fifth or sixth part of the vessel, and water it very well by degrees with the former solution of the salt armoniack, and immediately clap an alembick on the cucurbit, and fasten a receiver to the alembick, closing the joints very accurately; and from this mixture, by the gentle heat of a bath or a lamp, you may obtain a liquor, that smells much like spirit of urine, and seems to be much of the same nature: and this volatile liquor being once or twice rectified *per se*, with a very mild heat grows exceeding fugitive and penetrant, and works by sweat, and a little, perhaps, by urine. And I remember, that when I first made it, having been induced by some analogical experiments, I had formerly made, to give it to one, that had a patient troubled with an extremely violent cough, I had an account quickly brought me, that he not slowly, but wonderfully mended upon the very first or second dose; and indeed the trials, that have hitherto been made of it, make me hope, that it will prove little inferiour in efficacy to the other above mentioned more

costly spirits, scarce any of which being preparable by so safe and compendious a way, if this medicine emulate them in virtue, the easiness of the preparation (wherein little time needs be spent, and less danger of breaking vessels incurred) will much endear it to me. But, *Pyrophilus*, because I would assist you to make variety of experiments about volatile salts, and because divers trials may be more conveniently made, when the saline corpuscles are in a dry form, than when they are in that of a liquor; I will take this occasion to mention to you a way, by whose intervention a change on the fixed body employed about the newly mentioned experiment, hath sometimes afforded me store of volatile salt. This way was only to mingle exquisitely a quantity of sal armoniack, with about thrice its weight of strong wood-ashes. For the spirit, that we this way draw out of a retort placed in sand, did quickly in the receiver coagulate into a salt; and this method was again experimented with like success. And the salt thus made we found so extremely subtil and volatile, that it seemed to be much of the same nature with that of urine; and if it be indeed (as probably it is) only the volatile salt of the urine, and perhaps also of the foot, whereof the sal armoniack consists, this may pass for a more compendious way of obtaining such salts, than others, that are hitherto wont to be practised among chymists. But I will not undertake, that this way of obtaining rather salt than spirit shall constantly succeed. Yet if you find it do not, I shall not perchance refuse you a better way. But if you could devise a method (which possibly is not unattainable) of bringing over into a spirit, not the bare urinous and fuliginous ingredients of sal armoniack, but the whole body; it may be, you would have a menstruum, that would make good, if not surpass even *Renanus's* and *Glauber's* eulogies of the spirit of sal armoniack.

Of preparations of saline and sulphureous fetid liquors.

The way of making the common balsam, or ruby of sulphur.

THE affinity betwixt volatile salts and sulphurs doth, *Pyrophilus*, as well as your curiosity, invite me to acquaint you with some of the trials we have made about the preparation of sulphureous fetid liquors; which I am the more inclined to do, because, though I find mention made of some of them in chymical books, yet they are there delivered with so little encouragement, amongst many other processes, of which it appears not, that the prescribers made trial, that when I had distilled some of those sulphurs, divers expert chymists were very desirous to have a sight of them, to satisfy themselves, that such liquors could be so prepared. The way of making the common balsam, or ruby of sulphur, is too well known to need to be long insisted on. Only, because there is some little variety by several in the preparation, it will not perhaps be amiss to inform you, that we are wont to make it by mixing about three parts of oil of turpentine, with two of good flour of brimstone, and setting them on a strong urinal slightly stopped in an heat of sand, only great enough to make the liquor with a little crackling noise (whencesoever that proceeds) work upon the sulphur, till it be all perfectly resolved into a blood-red balsam, which will be performed in six, eight or ten hours, according to the quantity of the ingredient to be united. This balsam, which is indeed in some cases no despicable remedy, is by vulgar chymists according to their custom, very highly extolled, and sometimes employed in distempers and constitutions, wherein, instead of performing the wonders by them expected, its heat doth more harm, than its drying and balsamick properties, do good: but yet apparent it will be, by what we shall say anon, that by this preparation the body of the sulphur is somewhat opened, and therefore (as we said) in some cases the ruby of sulphur may prove no ineffectual remedy; which may probably be improved, if it be prepared by bare digestion in a very gentle heat, by which course we have prosperously prepared it, though not in so short a time, when we made it not in order to some other medicine.

To volatilize the sulphur thus resolved, we took the balsam made the former way, in a few hours; and putting it in a retort, either with, or without fair water, which is supposed to help to carry up the superfluous oil, we placed the vessel in a sand-furnace; and, with a gentle heat drawing off as much of the oil of turpentine, as would in that heat come over, we shifted the receiver, and carefully luted on the new one; and lastly, giving fire by degrees, we forced over a liquor of a deep and darkish red, extremely penetrant, but of a smell so sulphureous and diffusive of it self, that it was scarce to be restrained by corks, and was by great odds stronger than that of the ruby before distillation.

To volatilize the balsam of sulphur.

THE like experiment we tried in a glass-head and body placed in sand, and through that way likewise we obtained a volatile balsam of sulphur, yet we found it too inconvenient to be equalable with the former. What long digestions of this liquor will do, to take away, or lessen its empyreumatical and offensive odour, we have not yet been by experience satisfied, no more than of its medical virtues; though probably, the great penetrancy of the liquor considered, they will not be languid.

AUTHORS also prescribe the making a volatile balsam of sulphur, by driving over, after the above-mentioned manner, a solution of flour of brimstone in linseed-oil, and this remedy they highly extol; but though it may probably prove a good medicine, yet since they commend it but by conjecture, and not upon experience, I see no great reason, why it should be preferable to the other. For we find, that expressed oils are much more apt to receive an offensive empyreuma, than oil of turpentine; which being much more volatile than they, requires nothing near so violent a heat to make it ascend: and, unless it be found, that the sulphureous particles are able to mitigate the corrosive ones, the distilled liquor of an expressed oil may prove noxious in the body. For by purposely (for trial's sake) distilling oil-olive, by it self, though not in a naked fire, we obtained a liquor of that exceeding sharpness, that it would (taken inwardly) probably corrode, or fret either the stomach, or some other of the internal parts.

THERE is another way of preparing a sulphureous balsam, to which *Penotus*, no ignoble chymist, ascribes such stupendous virtues, that though I have not yet made trial of it in diseases, yet I dare not leave it altogether unmentioned; the process being briefly but this: Take good balsam of sulphur, made with spirit or oil of turpentine, and having freed it from its superfluous oiliness, pour on it well dephlegmed spirit of wine, and therewith draw, by affusion of new spirit as often as need requires, a sufficient quantity of a red tincture, which by filtration and abstraction *in balneo* must be reduced to a balsamick consistence. This liquor you may, if you please, by degrees of fire, drive through a retort placed in sand, and thereby obtain a volatile balsam of very great penetrancy, and probably of no small efficacy: but the trial I have made of this process, gives me occasion to advertise you;

Penotus his preparation of a sulphureous balsam, with the author's advertisement upon it.

1. THAT, unless your balsam be reduced to a stiff thickness, and almost to driness it self, the operation will hardly succeed; we having fruitlessly digested for some months spirit of wine upon balsam, whose consistence was somewhat too liquid.

2. THAT as soon as the spirit of wine is sufficiently tinted, it ought to be decanted, and succeeded by new; lest by too long digestion, instead of heightening its tincture, it let fall that, which it hath already acquired.

3. THAT upon a very slow abstraction of most of the tinted spirit in a digesting-furnace, we once found the remaining liquor not to be in the form of balsam, but to consist partly of spirit of wine, and partly of a seeming distinct oil, whereinto the sulphureous tincture was reduced. The balsam of sulphur thus made without distillation seems likely to be an innocenter and nobler medicine, than the common ruby of sulphur,

fulphur, made with a hot and ill scented oil of turpentine: and by this preparation may also appear the truth of what we formerly said, when we told you, that the body of the fulphur was opened by solution in oleaginous liquors: for out of the common thickened balsam, as you may be informed by this process, well rectified spirit of wine will, in a short time, extract a blood-red tincture; whereas by long digestion of spirit of wine alone upon pure, but undissolved, flowers of brimstone, we could not discern any change of colour in the menstruum; though I dare not deny the possibility of what some authors affirm, who write, that spirit of wine very excellently dephlegmed will in time, of it self, draw a tincture from flowers of fulphur, which tincture they yet pretend not to make of a higher than a lemon-colour. And, by the way, let me tell you, that our red tincture formerly mentioned is (if it be well made) so strong of the fulphur, that probably it would make a very penetrant, and effectual outward remedy in aches, and divers other cold distempers of the nervous parts; for it hath been already found, that good spirit of wine alone is one of the powerfulest fomentations in divers cases of that nature, (inasmuch that it hath been sometimes found to arrest the spreading mortification of gangrenes;) and therefore being so richly impregnated with fulphur, which is, even without the assistance of so subtile a vehicle, very available in many disaffections of the *genus nervosum*, it is probable, that the skilful association of two such active remedies may produce considerable effects.

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Of an excellent balsam of fulphur, made only with oil-olive. The common way of preparing it.

TAKE of pure flowers of fulphur one part, of the best oil-olive four or five parts; mix them well together in a strong earthen pot, able to contain a much greater quantity of the ingredients than is to be put in it; set this vessel over a moderate fire of charcoals, thoroughly kindled, till the oil, though slowly, have perfectly dissolved all the flowers of fulphur, which will (if you work it well) be performed in about half an hour, or an hour, (according to the quantity of your materials:) but you must have a great care, during the whole operation, first, that the oil catch not fire, whereby it would not only be lost it self, but perhaps endanger the firing of the house; and next, that the mixture be kept nimbly and constantly stirring from the first beginning of the oil's action on the fulphur, till the solution be fully made; and the pot (having been taken off the fire) be grown cold again. The chief signs, whereby you may perceive, that you have not erred in the operations, are, first, if the fulphur be perfectly dissolved in the oil, which you must often try, before you take it from the fire, by taking up with the tip of a stick, a drop or two of the liquor yet in preparation, and letting it cool on white paper, or on your nail, whereby you may discern, when the solution is perfectly made, by the deep redness, and transparency of the liquor, and by its containing no more in it any undissolved flowers of the brimstone; next, by the consistency of the balsam, which ought to be neither too liquid (as you will find it, if it hath not staid its due time on the fire; nor too thick (as it is apt to become, if you remove it not seasonably from the fire) but of the consistence of somewhat thin honey: and lastly, by the smell, which ought to be strong of the fulphur, but not of the fire; for though the sulphureous stink is, in this remedy, to be expected, that empyreumatical one, which proceeds from burning (and by skilful nostrils may be easily discerned) is very possible to be avoided.

THE dose of this balsam, when it is to be inwardly used, may be from two to fifteen, or twenty drops, according as the greatness of the distemper, and chiefly the strength and constitution of the patient shall require and bear. It may be given upon a fasting stomach, either alone, or brought to the consistence of pills, or of a bolus, with

with powdered sugar, liquorice, &c. or else dissolved in any convenient vehicle, wherewith its oleaginous nature will permit it to mingle. Outwardly it may be administered either by bare inunction of the part affected, or else by incorporating it with any other convenient ointment, or plaister: after which, we are wont to prescribe to have an application made to the part of two or three little bags filled with sand, as warm as the patient can easily endure it, and shifted as soon as either of them begins to cool, that by this means, the pores being opened, the virtue of the balsam, by being made more penetrant, may reach the farther.

I HAVE been thus particular, *Pyrophilus*, in the mention of this remedy, because though it seem but a slight and trivial preparation, yet experience hath given us a better opinion of it, than I fear the slightness of the preparation will as yet allow you, and indeed its virtues I am apt to think more than I have yet had occasion to observe: and therefore must refer you to *Rulandus* his centuries, where they are often mentioned. But outwardly in strains, old aches, bruises, and the like, it is wont to be very effectual; in the beginning of fits of the gout it hath several times (though not constantly) been prosperously applied both to Mr. B. B. and divers other persons, and sometimes it hath been found not ineffectual even in the sciatica itself. And as for paralytical distempers, I have had by a skilful physician an account sent me of scarce credible things, which it hath therein performed: to which I shall only add, that a while since I had great thanks returned me on the behalf of a fair young lady, to whom I prosperously prescribed it against a great tumour in her neck, which was supposed to be the beginning of the king's-evil: but this tumour was recent enough, which circumstance I think fit to specify, because I fear, that if the scrophulous tumour had been inveterate, the success would not have been so good. Inwardly the chief use we made of it hath been in coughs, and distempers allied thereunto; but its balsamick nature, making it both healing and resistive (if I may so speak) of putrefaction, makes it probable, that its virtues may be more extensive: to which purpose I remember, that a while since a friend of mine tried it with wonderful success in *miſtu sanguinis ferè deplorato*, having first by a gentle heat reduced it to such a consistence, as allowed him to make it up into pills. But of the particular cases, wherein our remedy hath been successful, no more at present; we shall rather subjoin, that though this have been the way, which we have the oftenest employed in the making of the balsam, yet we must not conceal from you, that we have divers times met with accidents, which frustrated our endeavours and expectations. For if the fire administered be too languid, the solution of the sulphur by the oil proceeds not well: and on the other side we have found, that not only a strong heat is apt to burn the matter, or to make the oil boil over, and perhaps take fire; but even that upon a very little excess in the degree of heat, the oil and sulphur would, before it could be expected, degenerate together into a heavy and viscous lump, (almost of the colour of the liver of an animal; which coagulated matter proved afterwards exceeding difficult to be by the affusion of fresh oil dissolved, and reduced to a due consistence. Wherefore we tried to prepare this balsam, by putting the proportion of ingredients formerly mentioned into a strong urinal, which we placed in sand, and making under it no more fire than was sufficient to make it slowly work upon the flowers, (which did often during their solution make a crackling noise;) we continued the operation for divers (perhaps many) hours, at the end of which, we found the sulphur dissolved, and the mixture reduced to a balsamick colour and consistence. So that if you distrust your dexterity to prepare this balsam by the former way with a naked fire, we must advise you to make use of this latter way, as that, which is the safer, though it be the longer way of proceeding. Nay, when we had leisure enough, we did for trial's sake, prosperously attempt the

Other ways
of preparing
this balsam.

solution

Resolution of flowers of brimstone, with common oil, by the far gentler heat of bare digestion, and by that means obtained a balsam perfectly free from aduſtion, but of ſomewhat too liquid a conſiſtence; which may be eaſily remedied by the mixture of powdered liquorice, ſugar, or any other ſuch convenient concrete. We muſt alſo advertiſe you, that this balsam may alſo be prepared with oil of nuts, of poppy-ſeeds, of hypericon, inſtead of oil-olive, or any other expreſſed oil, appropriated to the particular diſtemper, againſt which the phyſician intends to employ the remedy: only care muſt be had, that the ſpecifick qualities of the oil be not ſo fugitive, as to be deſtroyed by the ebullition requiſite to the making of the balsam; which if it be to be enriched with ſpecifick virtues in relation to any particular diſeaſe, may perhaps be beſt prepared by the laſt mentioned way (of digeſtion) wherein the ſubtile ſpirits, that impregnate the oil, are not in ſuch danger to be diſſipated by the fire.

A balsam of
antimony.

THE knowing chymiſts themſelves, *Pyrophilus*, are wont ſo much (and perhaps not altogether undeſervedly) to extol the efficacy of antimony, that we were thereby invited, beſides divers preparations of it for internal uſe, to attempt the making of ſome remedies of it, that might alſo be externally applicable; and in proſecution of this deſign, we found, that by boiling four or five fingers height of good oil of turpentine upon very finely powdered antimony, put with the liquor into a ſtrong glaſs urinal, placed in ſand, the oil after ſome hours would grow exceeding high tinged; and being gently in great part abſtracted, would leave behind it a body of a baſamick conſiſtence, and a deep redneſs: which may, I preſume, be applied to reſolve, and diſcuſs hard tumours, and remedy divers other outward evils, with more effect, than the ſimple balsam of common ſulphur formerly deſcribed. And from this antimonial balsam abſtracted to a ſtiffer conſiſtence, we found, that ſpirit of wine would draw a tincture, which I likewiſe ſuppoſe might prove a very powerful fomentation; though the ſpirit we uſed (perhaps becauſe it was not ſufficiently dephlegmated) did not in a few days attain to more than a very pale redneſs: but this tincture being ſlowly freed from the moſt part of the ſpirit of wine, became of the conſiſtence of ſomewhat liquid honey, and of a deeper colour, thereby affording us a purer balsam; which we have not yet, (being hindered by ſome accidents) attempted to bring over the helm. Nor did we here deſiſt, but by divers trials found, that the antimonial balsam, above mentioned, being put into a retort, placed in ſand, and preſſed by degrees of fire, would at length emit ſteams, which would condense in the neck of the retort, and fall thence into the receiver in ſanguine drops. This volatile red balsam (eſpecially if by this volatilization the antimony have loſt its emetick property) we cannot but think endowed with more than ordinary virtues, outward and perhaps inward too; conſidering the great penetrancy of the liquor, and the energy of the mineral, with whoſe ſubtle parts it is richly impregnated, if it conſiſt not mainly of them. But we are yet in proſecution of this preparation, and therefore till we have ſeen, how far we are like to improve this remedy, we ſhall forbear any farther mention of it; eſpecially ſince we have already, in this very paper, given you, as we ſuppoſe, ſufficient proof, that we are more ſollicitous for your ſatiſfaction and proficiency, than for our own reputation, (of being a ſevere critick in eſtimating of medicines) for otherwiſe we ſhould not have been ſo indiſcreet, as to acquaint you with any preparation, of whoſe medical virtues we have not yet made much trial, whiſt we are not deſtitute of other remedies, whoſe efficacy hath been maniſeſted to us by experience. But we have often obſerved, that divers uſeful chymical preparations are mentioned ſo obſcurely, and unintelligibly, by the authors that write of them, or elſe are without any particular, or encouraging note of diſtinction mentioned amongſt

Of the ob-
ſcure and
cryptical
way of writ-
ing of
chymiſts.

amongst a croud of other processes; some of which have perhaps already been found to be false, or trivial, and others of which may be rationally enough distrusted, that most physicians, and chymists themselves, are deterred from attempting to prepare those remedies; not so much because they seem unlikely to prove considerable, as because they are afraid, that the processes are false, or fraudulently set down; and consequently, that concretes of such a consistence, colour, scent, and other obvious qualities, as are ascribed to the remedies proposed, are not preparable by the published directions.

AND that you might see, *Pyrophilus*, what discouragements I have met with even from artists themselves, to keep me from trusting to printed chymical processes, I think it not amiss to mention here a memorable passage of the famous and experienced *Alexander Van Suchten*, who is reported to have gotten more by the practice of chymical physick than any of the contemporary professors of it: for he, towards the end of his book of the secrets of antimony (of which he clearly discloseth not any in that treatise) gives this account of his cryptical way of writing: *Quod in hoc tractatu nullum recipe proposuerim, ob id factum est, quod vos seducere nolo; recipe enim illa seducunt juniores medicos: sed neque à Theophrasto ullum recipe scriptum est, quod ad medicinam, quin occultum sensum habeat, & in quo nihil vel deerit, vel abundet, & hoc non fit sine magnis causis.* Wherefore I make account, that, besides that such changes of the qualities of bodies may afford much light to naturalists, he doth chymists no useles piece of service, that acquaints them with the success of the nobler sort of processes mentioned in authors, though he should give them little or no account of the virtues of the remedies prepared by those processes. But this I hope is not altogether our case: for besides that our observations are likely to save you much trouble, and perhaps some mistakes, and misadventures; besides that, (I say) we have had opportunity to observe such eminent effects of several of the volatile liquors described in these papers, as may justly give us promising expectations of the properties of the rest, which are in their obvious qualities so near of kin to them. And this sort of medicines having been found sometimes to do wonders, and generally to be safe, (which of a few of the known operative, and not specifick medicines, can be truly affirmed) I am apt to think, that he, that shall bring these remedies, in spite of their ill scent, into the good opinion of physicians, may make no inconsiderable number of patients beholden to him.

I SHOULD NOT, *Pyrophilus*, proceed to make you repent your curiosity to know my thoughts of the urinous, and sulphureous remedies it hath hitherto made me treat of; were it not, that there yet remains something to be said, without which, all that hath been said, will scarce signify very much towards the effectual recommending of those medicines to your esteem and practice.

FOR, I do not ignore, *Pyrophilus*, that not only the generality of the Galenical physicians, but divers of the more eminent and judicious of the chymists themselves, have been pleased to condemn the internal use of liquors, driven through a retort by the violence of fire, upon the score of their being offensively empyreumatical, and stinking: among which sorts of liquors I cannot expect, that our spirits of blood, hartshorn, &c. will escape the being reckoned. But forasmuch as the prosperous effects I have had opportunity to see, of divers remedies of that nature, have given me for them rather an esteem, than either a detestation or contempt; I suppose it may prove no unseasonable piece of justice to the spirit of blood, and the other noble, though fetid remedies I have been setting you down; nor no unserviceable piece of charity to men, if in this place, and once for all, I spend some lines in endeavouring to rescue these criminated medicines from the great prejudice they suffer under, and

Concerning the empyreuma of chymical extracts, and their offensiveness, compared with the Galenical, and those which are commonly used by the methodists.

from a reputation, which whilst it renders them more odious than even their smell can do, is likely to make men deny themselves the benefit of them.

And whether the offensiveness of divers chymical medicines proceed from the violence of the fire, or the nature of the matter.

I MIGHT here on this occasion call in question whether not only Galenists, but even many chymists themselves, be not somewhat more afraid than they need be, of what they call *Empyreuma*. But I will suspend a while that question, and at present confess to you, that I have sometimes doubted whether or no that stink, which is generally called by the newly mentioned name, do always and necessarily proceed from the impressions of a violent fire. For to make a pure spirit, and salt of urine, there needs nothing, but to let it in a well-stopt vessel putrify for a competent time (as we elsewhere teach) in a dunghil, or any resembling warmth, (and that it self, perhaps, is not necessary to its putrifaction) and then to draw off an eighth or tenth part of the liquor, that first ascends by the gentle heat of a bath: by which, or by the yet milder warmth of a lamp-furnace, it may be sufficiently rectified, and brought to yield, besides the spirit, good store of salt. And since the spirit thus made differs so little in smell or taste from those of blood and hartshorn, that most men's noses are not critical enough to distinguish them, (and we have sometimes taken pleasure to make chymists themselves to mistake the one of those liquors for the other) it seems worth considering, whether or no the fetid and urinous taste and smell, which in these spirits is said to be empyreumatical, and to proceed from the aduotion of the fire, be not the genuine taste and odour of the spirituous and saline particles of the mixed bodies themselves, which they would manifest, if they were copiously extricated (to speak in the king's language) separated from the other principles or ingredients, and associated into one body, though without the violence of the fire. For to distil the spirit of putrified urine, wherein the like smell and taste are eminent, there needs (as we said) no greater heat than that of a lamp-furnace, or of horse-dung, (since in the latter of these only, urine too long kept, and but negligently stopt, hath been observed to have lost its volatile salt and spirit, before it was taken out of the horse-dung. And such a heat seems not great enough to impress an empyreuma upon such a liquor: for we see, that most things distilled in the greater heat of a bath, are commended by physicians and chymists for their being free from empyreuma. And what activity may be acquired by the subtle parts of a mixed body, by the convening (if I may so speak) of such spirituous particles, disengaged from those other parts, which clogged or imprisoned them, without any empyreumatical impression from any violent or external heat, may appear by the chymical oils of spices. For though they be usually drawn by chymists and apothecaries, by the help of water in limbecks; and though they have by us been drawn after another manner, (which we may elsewhere teach you) with a much gentler heat (sometimes not exceeding that of an ordinary balneum) yet these well-dephlegmed liquors retaining so well the genuine taste and smell of the concretes they were drawn from, that they pass unaccused of empyreuma, are some of them much stronger and hotter than the spirit or salt of man's blood, or hartshorn. As may appear especially by the oil of cinnamon, which if pure, is more penetrant and fretting, than any thing but trial could easily have persuaded me. And lest you should object, that the fire doth considerably contribute to the strength of these liquors, otherwise than by disengaging the particles they consist of from the unactive parts of the concrete, and assembling them together: I must advertise you, that I have observed little less heat and penetrancy, than in divers of these, in some liquors separated without the assistance of distillation: as for instance, in the purer sort of the true Peruvian balsam, and in another kind of natural balsam, almost of an amber colour, which belonged to an eastern prince (who carried it up and down with him as a jewel) whose domesticks at his death sold it, whereby I came

to procure some of it, and found cause to wonder at its strength both upon the tongue and in its operation. But granting, *Pyrophilus*, that the volatile remedies treated of in these papers may have their offensive smell and taste imputed to the fire, yet perhaps physicians would more slowly and more tenderly censure the remedies in question for their empyreumatical stink, if they did but consider, that they themselves scruple not to use (to name those among many others) fenna and scammony, though the former be wont to gripe the guts, and the latter have an acrimony, heat, and mordacity so unkind to the bowels, that a few grains exceeded in the dose turns it into poison; because the ill qualities of these medicines may, by proper correctives, be somewhat mitigated; and the good they do, doth more than countervail the inconveniences, that attend the use of them. For the very same considerations, *Pyrophilus*, will be applicable to the excuse of those fetid medicines, for which we apologize. For though the empyreuma or impression of the fire, for which they are rejected, be the quality, whose absence from them were very desirable; yet may that empyreuma by dextrous preparations be in some measure corrected, (inasmuch that I have known highly-rectified spirit of urine, by being digested for divers months in an exquisitely stoppt glass, brought to be of a scent, which to me seemed scarce at all stinking, and to others even pleasant) and the prejudice, that may be justly feared from what remains, is advantageously recompensed by the benefits accruing from the efficacy of their more friendly endowments. And in effect we find, that the dogmatists themselves are grown not to scruple the administering the spirit of salt, though extorted (if it be of the best) by a much greater stress of fire, than is requisite to the distillation of any of the medicines we defend. And not only the famous *Riverius* (as we have elsewhere noted) extols the spirit of tartar, and foot, which are yet sufficiently fetid and empyreumatical, but several other (and amongst those some of our eminent English) physicians frequently use, and commend the oil of guaiacum, forced through a retort. And no less do divers learned doctors esteem, and employ the empyreumatical oil of amber; though (to note so much by the way) that be in divers cases far inferior to the volatile salt, which (if the fire be skilfully administered) may at the same time, and by the same operation, be obtained. This salt, besides the efficacy ascribed to it in the convulsions of children, having been lately found by experience to be an excellent medicine against the epilepsies, even of well-grown persons, being administered in the dose of not above a scruple or half a drachm, in a due quantity of piony-water, or some other proper vehicle.

AND on this occasion, you may also be pleased to take notice, that foliated gold is ordinarily and without scruple employed by physicians, not only to cover pills, but as a main ingredient (though how properly, I define not) of several of their richest cordial compositions extant in dispensatories; and yet to how great fire gold is wont to be exposed before it be melted out of the ore (wherein it is usually, at least as far as we have observed, blended with other metals, and minerals) and to purify it upon the cupel, either with lead, or antimony, he, that is unacquainted with the operations of mineralists, and the art of refiners, will not easily imagine. And, *Pyrophilus*, to satisfy you yet farther, that the strong impression of fire in the medicines does not always make them so noxious, as they are commonly reputed; let me desire you to take notice, that there is scarce any medicament more generally given, and applauded, even by methodical physicians, than steel, which is often administered in substance, made up with other ingredients, into the form either of pills, or electuaries. And yet we have wondered to see, what great fires, and violent blasts of huge bellows, moved by water-engines, are used to melt iron first out of the stone; and if it be to be farther refined into steel (much of that used in physick being

factitious) a new violence of the fire is requisite. And though after all this, to make astringent *crocus per se* (which is accounted one of the best preparations of it) they are wont to keep *Mars* (as the chymists speak) amidst reverberated flames, or in some glass-man's furnace for many hours, yea sometimes for divers days; yet this medicine is, with more success than scruple, daily administered by learned physicians, in dysenteries, fluxes, and other distempers, where attrition is required. And it is somewhat strange to me, that the having been exposed to no greater fire, than is requisite to distil spirit of blood, or of hartshorn, should be much urged against those medicines by those, that scruple not to commend, and do almost daily, and oftentimes successfully, prescribe the lixivate salts of plants, and particularly of wormwood, though these are not rightly made, but by the exposing the concretes even to the violence of an incinerating fire. And as for the unpleasantness of the smells of our spirits of blood, hartshorn, &c. besides that, to very many persons there is no odour so loathsome, as that of a potion; we find, that the Galenists themselves scruple not, in the fits of the mother, (which yet very rarely prove mortal) to repress (as men are wont to suppose) the unruly fumes by the smell of castoreum, assa foetida, and even the empyreumatical odour of the burnt feathers of partridges: nor do they decline to use these homely, and ungrateful remedies to the patients of the tenderest sex, and highest quality; and indeed in dangerous cases, I have known, fair ladies content to think it fitter to take down an ill-scented medicine, than venture the having their own bodies, in few days, reduced to worse perfumes. And certainly we may justly say of health, as no less than an emperor said, of the gain brought him by urine, that *it smells well, from what thing soever it comes.*

Ways of
taking off
the fetid-
ness, from
spirit of
urine,
hartshorn,
&c.

BUT, *Pyrophilus*, if your nostrils were so nice, that they must needs be complied with, though with the hazard of impairing the virtue of the salts they are offended with, I could propose an effectual expedient to gratify them; and being now invited by so pressing an occasion, I shall not scruple to annex something of it, and tell you, that if we may judge of the virtues of the spirit and salt of foot (which I am wont to make without addition) by their sensible qualities, they must be much of kin to those of the spirit of hartshorn, and of urine; (though these be animal substances.) And therefore having elsewhere more particularly, and by divers experiments, declared the affinity between these salts in divers regards; it will not, I presume, be looked upon as an unuseful or unseasonable hint, if I give you a summary, though but imperfect account, of what I remember my self to have done, in order to the freeing of the volatile salt of foot, from that very offensive smell, which may possibly make many, even of those that need them, abominate those medicines, how piercing and noble soever, which it blemisheth. The process is as followeth:

TAKE a quantity of a well-dephlegmed spirit of wine proportionate to the quantity of salt, whose odour you desire to correct; into this spirit, drop as much oil of rhodium, or of any other odoriferous chymical oil, as will suffice to make the liquor as strongly scented as you desire it: shake the oil and spirit well together, and if they were both well made, the latter will imbibe the former, and sometimes be thereby turned into a whitish substance; with which, if it smell not strong enough of the oil, you may by agitation incorporate more oil; and if you judge the mixture too strong already, you may dilute it at pleasure, by the affusion of more spirit of wine. This done, put the salt of foot into a bolt-head, or glass-egg, (according to the quantity, that you intend to sublime) furnished with somewhat a long neck or stem, and afterwards pouring on leisurely your odoriferous liquor, you may with it wash down the salt, that is wont to stick in the neck of the glass. After this, you must very carefully stop the vessel with a cork, and store of hard wax, if you cannot conveniently make use of an exacter way

of covering it. This glass you must place in a lamp-furnace, or some other, wherein you may give a very moderate heat, for that will suffice to elevate to the neck and upper part of the vessel, the pure white salt of foot, imbued (at the second time, if not at the first) with the scent of the odoriferous oil, which you employed about the preparation.

THIS experiment, *Pyrophilus*, may prove of that use in physick, that it may deserve as well for its nobleness, as the watchfulness, which is requisite in him that makes it, to be illustrated by the ensuing

OBSERVATIONS.

1. THEN it is requisite, that the spirit of wine be very good. For that, which is not sufficiently dephlegmed, will not readily and perfectly receive into it self the odoriferous oil, wherewith it is to be performed. Nor would every chymical oil, although it were well scented, be fit for this preparation; for divers of them, as oil of turpentine, and oil of amber, will not sufficiently mingle with spirit of wine, unless they be previously subtilized after a peculiar manner.

Observations concerning this method of taking off the empty reuma.

2. THE proportion betwixt the spirit of wine, and the oil that it is to be dissolved in, it is not easy to determine; for a lesser quantity will suffice of some oils, than of other. And the proportion of them must be varied, according as you would have the sublimed salt to participate more or less of their odour, and other qualities.

3. GREAT diligence must be used in closing the top of the glass, because of the great fugacity, and subtilty of the salt, whose avolation is to be prevented: but then much greater care is to be had, that the heat be not too strong, but as equal as may be, and much inferior to the moderate heat of an ordinary chymical balneum. For it is scarce credible, how easily this unruly salt will be excited either to make an escape at the mouth of the glass, or to break it in pieces. And I remember, among such other accidents, which have befallen us in the preparation of this odoriferous salt, that having once set some of it to sublime from a perfumed chymical oil, though we administered so gentle a heat, that we thought the vessel out of all danger of being broken, or found open; yet in a short time, the fugitive salt did with a great noise blow out the cork, that was waxed to the top of the vessel, leaving in the bottom not a limpid oil, but a liquor of a red-colour, and a balsamick consistence. But if the glass be wide enough to allow these fumes competent room, and if the heat be warily administered, the sublimation may be well enough performed.

OF the medicinal quality of this aromatical salt, *Pyrophilus*, we have not yet had opportunity to make trial; but some esteem may be made of them, by calling to mind the virtues of the simple salt of foot, and considering the nature of the liquors, from which in this our preparation it hath been sublimed. The principal, if not the only thing, that seems to be feared, is, that the salt of foot being itself hot, and chymical oils being for the most part eminently so too, our salt may prove unfit for men of hot and cholerick complexions, and in such distempers as proceed from excess of heat. But then it may considered in the first place, that the salt of foot, being of an extremely aperitive, resolving, and volatile nature, and carrying up with it in sublimation, only the more fugitive parts of the liquor, from which it is sublimed; it is very likely, that the heat produced by a medicine, which by reason of its fugacity would stay but a very short time in the body, will not be so lasting as that of ordinary sudorifics, which are nevertheless often administered with good success, even in hot diseases.

Of the medicinal quality of these aromatized salts.

SECONDLY, That there are divers bodies and distempers, wherein remedies may be the more proper, for their being somewhat hot; and experience shews, that in dropies

(to.

(to mention no other diseases) these volatile saline remedies, that set the blood a whirling, and powerfully promote its circulation, may prove very available.

THIRDLY, The heat, that may be feared upon the use of our salt, may be either prevented, or at least moderated by the seasonable use of such cooling remedies, as may be no enemies to the operation of this salt, and yet no friends to the distemper, against which it is administered.

AND lastly, supposing, that the inconveniences proceeding from this heat are not to be altogether avoided, yet the advantageous efficacy of so powerful and searching a remedy may very much outweigh that inconveniency: and therefore *Riverius*, as we formerly told you, commends the spirit of foot (though that seem at least as hot as the salt) in pleurisies; and in the same hot sickness, we have, as we elsewhere relate, successfully administered the spirit of hartshorn, whose qualities are very near of kin to those of salt of foot. Other instances of this nature you may meet with, dispersed in other passages of my chymical papers: to which I must add, that upon the consideration above-mentioned, the methodists themselves make no difficulty, in pills and other medicines, to use the chymical oil, either of cloves, or of nutmegs, or even of cinnamon. And some of our eminentest English doctors, as I lately noted, have not scrupled of late years to use the strong and fetid chymical oils of amber and of guaiacum, (and the latter of these in large doses) whereas in our preparation, only the finest and most aromattick parts of the oils seem to be associated with the fuliginous salt, since the oil remaining after the sublimation has been observed to be thick and ropy almost like a syrup.

BUT whether or no this aromattick salt be a safe medicine in all hot bodies and diseases, it seems very probable, that it will prove a very powerful remedy in those distempers, for which it is proper. For first, whereas Spagyrist have, with much study, but without much success, endeavoured to make oils capable of being mixed with other liquors, by depriving them of their oleaginous form, in which *Helmont* himself complains, that they are offensive; we have, by our preparation, their finest parts associated with the penetrant and volatile salt: by whose assistance they are not only fit to communicate their virtues to liquors, but assisted to penetrate exceedingly; and perchance also, thereby to obtain such an access to the innermost parts of the body, as is seldom allowed to vegetable medicines. Secondly, we may have by this preparation one of the most noble and volatile salts of the world, not only freed from its stink, but imbued with the odour, and perhaps divers of the virtues, of what chymical oils we please. And since these chymical oils are by chymists and naturalists thought to contain the most noble and active parts of the vegetables, whence they have been distilled; and since also the salt of foot sublimed from them carries up with it the finest parts of these oils, why may it not be hoped, that no small number of distinct remedies may be afforded us by this single experiment? These remedies too may be the more acceptable both to physicians and patients, because they have not in them any thing, that is mineral; and notwithstanding their great penetrancy and efficacy, have in them nothing of corrosive, as many of the saline remedies prescribed by physicians in their dispensatories. And thirdly, that the salt of foot thus sublimed may be also enriched with the sulphur or balsamick part of the spirit of wine, which was employed about its preparation, may appear probable enough to him, that shall examine, by his taste and otherwise, such rectified spirit of wine, as has had a sufficient quantity of volatile salts sublimed from it. And how balsamical a substance is diffused through pure spirit of wine, may be guessed at by the great change, which is made in the caustick salt of tartar, when it is so dulcified, as to make that excellent medicine, which *Helmont* extols against inward ulcers, and calls *Balsamus Samech*; which if one had

had the abstruse art of so preparing the salt and liquor, as to fit them for conjunction, might be made only by distilling very frequently pure spirit of wine from very fine salt of tartar. For by this means the fixed salt, retaining the sulphureous salt or balsamick parts of the spirit of wine, (as may appear by the aquosity of the liquor, that comes over the helm in this preparation) is thereby so deprived of its caustick taste, that when it will rob no more spirit of wine, but suffer it to be drawn off as strong as it was poured on, it will easily in a moist place run *per deliquium* into a liquor, not of a caustick, but balsamick (and, as it seemed to us, a pleasant) taste.

AND whereas, *Pyrophilus*, we have complained of the difficulty we have met with, to manage the unruly salt of foot, and keep it from breaking prison, we must, to make this experiment be more practicable and useful, advertise you, that you may, if you please, instead of salt of foot, aromatize that of hartshorn, or man's blood. And I might add, that a very ingenious friend of ours, Dr. N. N. has lately practised yet a more easy and preferable way of preparing medicines of this nature: but though I have partly tried his method, and found it to succeed well enough; yet since I had it but by communication from him, and that he makes a considerable advantage of it, I must forbear imparting it to you, till I shall have obtained his consent to disclose it.

I KNOW not, *Pyrophilus*, whether I shall need to add, that of these fetid remedies, which are volatile, and somewhat sulphureous, as I chose to mention to you but a few, to comply with my present haste, which would not allow me to insist on many: so in what I have delivered concerning these few, I have set down particulars the more fully and explicitly, because I find the doctrine of volatile salts (though in my poor judgment worthy of a serious inquiry) perfunctorily, and indistinctly enough, handled by the chymical writers I have yet met with; which made me the willing to contribute the few observations I could readily find, of those I have had opportunity to make about them, towards the illustration of so important a subject, of which having elsewhere spoken in relation to physiology (as these fugitive bodies belong to the commonwealth of salt) I thought it might not be unacceptable to you, if I also considered them a while in relation to physick, and presented you with some hints concerning their medical uses.

To the 136th Page,

[Where the author promises a declaration, how he would have his praises of medicine understood.]

AND now, *Pyrophilus*, having finished what I thought fit to add (at present) in the past appendix; I should likewise put an end to the present exercise of your patience; but that this being my first treatise written to you concerning medical matters, and not being likely to be the last, which you will meet with among the papers designed you, I think it requisite, and not unseasonable to declare to you here once for all, with what eyes I desire you should look upon what I have written, and shall write, to you concerning matters of that nature. And first, I must advertise you, that I am not so much a mountebank, as to recommend to you the remedies I mention as certain cures in the cases, wherein they are proper. For he must have been extraordinarily happy, or very much unacquainted with the practice of physick, that has not found, that even those medicines, which are most celebrated by the best authors, both Galenical and chymical, do sometimes prove ineffectual as well as often prosperous; and the remedy prescribed by the same physician to twenty patients sick of the same disease has more than once been observed, though it have succeeded in nineteen, to fail in the twentieth. And indeed the causes of diseases, the constitution of patients, and the complications of distempers are so very various, intricate, and obscure, that it is extremely difficult

even

even for the most knowing and experienced physician, to make an accurate and constant experiment in the therapeutical part of physick; and consequently such experiments are much less to be expected from me, whose condition as well as disabilities forbid me to make the practice of physick my business, and allow me only to administer it occasionally, either to my own particular acquaintance, or to such poor people, as are not able to gratify physicians, or to such as I meet with, where there are not any: and thereby I am reduced to learn the virtues of divers of the remedies I have prepared by very few or none of my own immediate trials, but the relation of physicians, who do me the favour to administer them for me. And therefore, though I endeavour to put them into the hands of faithful as well as ingenious men; yet not being allowed to be my self a constant eye-witness of the effects they produce, I must here for all these reasons solemnly profess to you, that as I do not set down medicinal experiments with the same positiveness, that I do physiological ones, so I do not intend to venture the repute of being a faithful relater of experiments, upon the success of any medicinal receipt or process.

YET in the next place I must tell you, that you would perhaps do me but right, to think, not only that the chymical preparation of remedies are, if you understand them aright, candidly set down, though the virtues ascribed to them do not constantly upon all trials display themselves; but that I have not rashly and inconsiderately, or upon uncertain rumours, recorded the virtues of particular remedies, which may be good, though they be not infallible; it being sufficient to make a medicine deserve the title of good, that it be often (in some degree at least) successful, though now and then it prove not available; especially if it be otherwise so safe and innocent, that even when it proves not prosperous, it weakens not nature, nor is otherwise noxious. And we must not, *Pyrophilus*, be so timid, as to suffer ourselves to be persuaded, that if a patient miscarry after the use of the remedies, the fault must necessarily belong to the exhibited medicine. For oftentimes nature will in spite of remedies make a metastasis of the peccant matter, and so impair the condition of the patient; and much oftner before death, the conflict of struggling nature and the conquering disease doth manifest itself in horrid and dreadful symptoms, which some envious or ignorant doctors (for the more learned are wont to be more equitable, and less partial) injuriously impute to the chymical remedy, given before the appearing of those symptoms; never considering, that the like accidents are wont to attend dangerous diseases, and dying persons, where Galenical remedies only, and no chymical ones at all, have been administered. And that divers of the most eminent, and methodical of our modern physicians scruple not to use frequently both *crocus metallorum*, *merc. dulcis*, and some other chymical remedies, and to impute the miscarriages of the patients, that use them to their diseases; though not many years since, all the frightful symptoms accompanying the dying persons, to whom they had been exhibited, were confidently imputed to those medicines. To which let me add, *Pyrophilus*, that oftentimes it may be very just to prize an empirical remedy more than a Galenical, though the methodist and the empirick have each of them, by his respective remedies, performed cures of divers patients in the same disease; partly because empirical chymists are seldom resorted to but in desperate cases, or till nature be almost spent, either by the violence of the disease, or the unprosperous operation of the medicines employed to remove it; and partly, because the methodist helps his remedies, by premising the wonted evacuations (by vomit, siege, or by phlebotomy) by varying them according to emergent circumstances, by skilfully and seasonably administering them, and by strict rules of diet; whereas the empirick oftentimes useth but a single remedy, and usually without premising general evacuations, exhibits it not to the greatest advantage in relation to him, and other circumstances, and is much more indulgent to his patient in point of diet:

Divers disadvantages of chymical and empirical physick in the way of administration.

so that when an empirick and a rational physician do, both in several patients, cure, for instance, the same pleurisy, the disease may be very often judged to have been removed in one of the patients chiefly by the physician, and in the other by the remedy.

IN the third place, *Pyrophilus*, I must advertise you, that though I mention more chymical remedies than Galenical, yet it is not out of any partial fondness of the former, and much less from any undervaluation of the latter; but partly, because chymical processes being wont to be more unfaithfully, or obscurely, set down by authors than Galenical receipts, I thought it might save you some labour, to receive from me a frequenter account of those, than these; and partly, because in many chymical preparations, divers considerable changes being to be wrought upon the concretes to be prepared by them, there is oftentimes so much of philosophy to be learned by such processes, that the success of them may prove instructive to you, though it should acquaint you with their truth only, as they are chymical preparations, and not as they are medicinal receipts. But otherwise I love to look upon both chymical and Galenical remedies with an impartial eye, and think, that neither the former ought to be despised for the latter, nor the latter for the former: for as chymical remedies have commonly the advantages of being more durable, less clogging by their quantity, and less nauseated by patients; so Galenical remedies have, when they are of equal efficacy, the advantages of being more cheap, (at least quantity for quantity) more procurable, and sooner prepared. And such is the variety of cases arising from the variety of constitutions and distempers, that in some of them the former sort of remedies may be more proper, and in others, the latter may seem requisite; and in some also, both sorts may alternately be so useful, that neither of them can well be spared.

That chymical processes stand more in need of clear relations, than Galenical.

IN the fourth place, *Pyrophilus*, let me advertise you, that divers chymical remedies and some specifics also, which are not chymical, have seemed upon trial less effectual than indeed they are, because they have been tried by such physicians as weaken their efficacy, by not administering them as they should. For some physicians will never exhibit a chymical remedy, till the patient's strength hath been almost tired, if not quite spent with the unprosperous use of divers others clogging and debilitating medicines. Others are so diffident of chymical remedies, that they never dare to exhibit them in a full dose, nor by themselves, but will blend a small quantity of a chymical medicine, or a specifick with other ingredients, which either constitute, with it, a medicine of new qualities, resulting from that mixture, or at least, much clog or enervate the activity and virtue of the chymical or specifick ingredients: by which, even in so inconsiderable a dose, these distrustful doctors dare yet require, that great matters should be performed. Of which injurious way of administering the remedies I recommend to you, *Pyrophilus*, I do not causelessly desire you to beware; as I may hereafter have occasion to shew you, by particular instances, of the reasonableness as well of this advertisement, as of the others, which I either have given you, or shall give you, in this and other papers. And another sort of physicians there is, who are of so despondent and rather partial an humour, that if a chymical remedy, or a specifick, do not presently perform the hoped-for cure, though they find, that, even upon their disadvantageous manner of administering it, it doth good, yet they will quickly desist from the use of it; and because it doth not do wonders, they will not scruple to affirm, that they have tried it, and found it do nothing: whereas they are wont to continue their own courses of physick without discouragement, though it be usually some weeks before the patient find any good by them, and oftentimes (as numbers of the printed observations of physicians, as well

Errors in the time and dose of chymical remedies.

as daily experience testify) the patient is, by the tedious course of physick he has gone through, very little bettered, if not much impaired. Which I speak, *Pyrophilus*, not with an intention to disparage physicians in general, the most learned and ingenious of them being free enough from the partiality I here take notice of; but to keep good remedies from being disparaged by the envious or unskilful trials of bad administrators. And though indeed some chymists are so vain-glorious or unwary, as to promise, that the operation of their remedies should be as well sudden, as effectual; yet if the medicines themselves be found available, although not swiftly so, that slowness ought to make us but condemn the boastings of the man, not reject the use of the remedies.

AND in the last place, *Pyrophilus*, I must advertise you, not to expect, that every one of the remedies I commend should be physick and physician too: I mean, that it should of it self suffice to perform the cures of those diseases, against which it is commended. For medicines are but instruments in the hand of the physician, and, though they be never so well edged and tempered, require a skilful hand to manage them: and therefore I cannot but admire and disapprove their boldness, that venture upon the practice of physick, wherein it is so dangerous to commit errors, barely upon the confidence of having good receipts. For though, by conversation with eminent physicians, I have found the learnedest of them to disagree so much about the nature and causes of diseases, that I dare not deny but that he may prosperously practise physick, that either ignores or dissents from the received doctrines of the schools concerning the causes of diseases, and some other pathological particulars; yet I cannot but dislike their boldness, who venture to give active physick, either in intricate or acute diseases, without at least a mediocrity of knowledge in anatomy, and so much knowledge of the history of diseases, as may suffice to inform them in a competent measure, what are the usual symptoms of such a disease, what course nature is wont to take in dealing with the peccant matter, and what discernible alterations in the patient's body do commonly fore-run, and thereby fore-tell a crisis, or otherwise the good or bad event of the disease. To all which is to be added some tolerable measure of knowledge, not only of the *materia medica*, and the chief ways of compounding several ingredients into medicines of several forms and consistencies, as circumstances may require; but also of the orderly and seasonable administration of the helps affordable by them. These particulars, *Pyrophilus*, might easily be enlarged on; but having neither the leisure nor design to handle them common-place like, I shall only give you this account of my requiring, in the professed practitioner of physick, some knowledge both of the *materia medica*, and the method of compounding and administering remedies, that (excepting perhaps the *arcana majora*, as chymists call them) even the best medicines, by being unseasonably or prosperously administered, especially in acute diseases, where nature's motions are to be diligently watched, and seconded, may do a patient as much harm, as the orderly and skilful administration of them can do him good. And that he, that has nothing but one good receipt for a distemper, and knows not how to vary it by adding, omitting, or substituting other parts of the *materia medica*, as urgent occasion shall require, may oftentimes find himself reduced either to suffer his patient to languish helpless, or to venture by curing him of one disease to cast him into another. For sometimes the patient's constitution makes the medicine prescribed by the receipt unfit to be administered; and sometimes too the disease, for which the receipt is proper, is in the patient complicated with some other distemper, which may be as much increased by the specific, as the other disease may be lessened. I know, for instance, some eminent men, that are wont to cure very stubborn venereal distempers, by a chymical pre-

That a competent measure of knowledge is absolutely necessary to a practitioner of physick.

paration (which some of themselves have been pleased to disclose to me) of the Indian plants, sarsaparilla, guaiacum, &c. But if these men met with patients, such as those, which *Eustachius Rudius* mentions himself to have often met with, who, upon the use of the least quantity of guaiacum, though corrected with cold ingredients, were wont to be presently affected with such sharpness of urine, and inflammation of the parts, to which urine relates, as hazarded their lives; they would be reduced, as well as our author confesseth himself to have been, to have recourse to mercurial or other remedies. To which we may add, that the use of sarsaparilla, and guaiacum is generally forbidden by the warier sort of physicians, in those patients, whose venereal distempers are complicated with heat or inflammation of the kidneys or liver. And sometimes also it happens, that the very outward form of the medicine prescribed by the receipt, is not fit, or perhaps possible to be administered: for, not to mention, that divers patients can retain no purgative physick exhibited in the form of a potion; and some others are as apt to vomit up, whatever is given them in the form of pills; not to insist on this, I say, I shall content my self, to relate to you a memorable case, that happened a while since to a physician of my acquaintance. He was called to a lusty young woman, who, upon an accidental but violent cold, was suddenly taken with such a constriction of the parts inservient to speech and deglutition, as made her altogether unable either to speak or swallow any thing at all: and having thus continued some days in spite of clysters or other remedies, prescribed by a very learned physician, and in spite of endeavours to excite vomiting, by making her hold emetick things in her mouth; the poor woman was in great danger (when my acquaintance came to her) of perishing for hunger. What in this case could be expected from the best remedies, that must necessarily be taken in at the mouth? Wherefore the physician finding her yet strong enough, and without fever, and yet her case almost desperate, did as judiciously as luckily prescribe a clyster, wherein to ordinary ingredients were added (as himself a very few days after told me) about four ounces of the infusion of *crocus metallorum*, with an advice, that it should be kept in as long as possibly she could; and by this medicine, nature being sufficiently irritated, there quickly followed upon it some violent vomiting, and upon them a liberty both of swallowing and speaking. [And since this, a young gentleman and fellow-traveller of mine had the organs of deglutition so strangely weakened without any manifest cause, that though he were able to make me a visit, and acquaint me with his case, yet he was very apprehensive, he should in a very few days be starved; and being unable to swallow remedies, had quickly perished in despite of the *arcana majora* themselves, had he been master but of such of them as (like those wont to be magnified by chymists) must be taken into the body; if a very happy physician, to whom I directed him, had not by a very efficacious and specific medicine, externally to be applied, seasonably rescued him from so unusual and desperate a case.] But, *Pyrophilus*, as I would not, upon the score of good receipts, have the physician's skill despised, or thought useles; so I wish, that the physician's skill may not make him despise good receipts. For we have often seen (especially in outward affections) not only empiricks and chirurgeons, but even ladies and old wives, with a lucky composition prescribed by a receipt, perform more constant and easy cures of the particular distemper, for which that receipt is proper, than even learned physicians by their extemporary, though pompous and artificial prescriptions. And the illustrious Lord *Verulam* (one of the most judicious naturalists, that our age can boast) thinks fit to take notice of it as a deficiency, that receipts by long experience approved are not more closely, and, as he speaks, religiously adhered to, but altered upon every light occasion. And in the same chapter, to answer the principal

The Lord Verulam's judgment, that approved receipts ought not to be altered, but religiously adhered to.

Crato's judgment had herein, and the author concurs with that eminent physician.

Confil. 322.

Helmont. in Arcan. Paracelsi. pag. 787. Of the greater arcana, and more universal medicines, the efficacy of which may compensate for want of skill in the prescriber. Helmont. in Arcan. Paracelsi. pag. 790.

as well as the most obvious objection in this matter, 'That, says he, any man induced by some specious reason should be of opinion, that it is the part of a learned physician (respecting the complexions of patients, their age, the season of the year, custom, and the like) rather to accommodate his medicines as occasions suggest, than to insist upon some certain prescripts, is a deceivable assertion, and which attributes too little to experience, too much to judgment.' And a little above, he goes much farther than we pretend to do; for speaking of the neglect of the use of particular receipts, which, as he speaks, by a kind of propriety, respect the cure of particular diseases, he adds, severely enough, 'that the physicians have frustrated and taken away the fruit of traditions, and approved experience by their magistralties, in adding, and taking out, and changing ingredients of receipts at their pleasure, and almost after the manner of apothecaries, putting in *quid pro quo*; commanding so presumptuously over the medicine, as the medicine can no longer command the disease.' Thus far our judicious author: But I will rather chuse to express to you my sense on this whole subject of receipts, in the words of that experienced physician to three emperors, *Johannes Crato: De morbi natura* (says he) *causa, locoque affecto, medicus diligenter cogitet, atque in eo plus quam in certis medicamentorum mirificis formis situm putet. Medicinam tamen expertam cum ratione adhibitam plus valere quam ea, quæ interdum subito à doctissimo etiam medico magna ratione exhibitæ excogitatur, non dubito: atque hac in parte rationales etiam medicos empiricis cedere debere de sententia Hippocratis statuo.* Only I must add by way of explanation, that this sentence is to be understood to express my sense, when the medicines used are not very extraordinary, but such, as *Crato* employed, and hath left us in his writings: for there may possibly be such effectual specifics, and such powerful and commanding remedies, that the efficacy of the medicine may (at least in some particular diseases) excuse and repair much want of skill in the prescriber.

If the testimony of *Helmont* concerning the *Arcana* of *Paracelsus* be considerable, even in a tract (where either out of emulation or judgment, he endeavours somewhat to depreciate both them and their author) much greater things might be boldly affirmed of some *Arcana*; for *Fateor lubens* (says he, speaking of *Paracelsus*) *me ex ejus scriptis profecisse multum, illumque potuisse, per remedia ad unitatis symbolum ascendentia, sanare lepram, asthma, tabem, paralyfin, epilepsiam, calculum, hydropem, podagram, cancrum, atque ejusmodi vulgo incurabiles morbos: attamen Paracelsum fuisse ignarum radices vitæ longæ, tam ex ejus scriptis & medicaminibus quam ex obitu collegi, &c.* And in the same tract, just before he comes to enumerate *Paracelsus's Arcana*, *Concedo*, saith he, *universales aliquot medicinas, quæ sub unisono naturæ longè gratissimo, insensibiliter post se victum educunt hostem, cum egregia organorum depuratione; concedo pariter appropriatas aliquot quo universalis amplitudinem in specificis morborum directionibus æmulantur.* And among those *Arcana* themselves, that is ranked but in the second place, of which he gives this character; *Sequitur dein mercurius vitæ, sibi proles integri, quæ omnem morbi nervum penitus absorbet.*

AND because another *Arcanum* doth not so powerfully renovate, as that last mentioned, and two more; he allows to those three others the precedencies of that, whereof he yet saith, *Quarto loco est mercurius diaphoreticus, melle dulcior, & ad ignem fixus, solis horizontis omnes proprietates habet: perficit enim quicquid medicus & chirurgus possint optare sanando.* But because, that any medicine should be qualified to deserve such superlative encomiums, may seem a thing fitter to be wished than credited, I would not dissuade you, till the chymists cures have made good their masters brags, to be altogether of our author's mind, who somewhere professes, *Se morbum non distinguere, si remediis* (sure he speaks of such remedies, as he thought he had) *sit summa*

summa bonitas. But yet you may perchance ascribe much more even to remedies far inferiour to the *Arcana majora*, in the cases, wherein they are most proper, than many are willing to believe. Insomuch that I have sometimes observed with wonder, that an excellent person (whom I need not name to you) cures the rickets generally in children of several ages and complexions, without having hitherto failed (as she professes) in any one, by prescribing no other remedy, than the single use of the above described colcotharine flowers, which I presented her with. And a couple of physicians also, to whom I recommended them, tell me, they have tried them in the same disease with the like success, as this lady hath hitherto met with. And I remember, that eminently learned and experienced physician Dr. G. Boat, (of whose skill both your excellent mother and you have had good proof) solemnly assured me, as I elsewhere also note, that he knew a physician, who constantly cured within two or three fits all agues, whether recent or radicated, in persons of all ages, sexes, and complexions indiscriminately, with one single outward application to the patient's wrists; but that this envious doctor would never part with it to our friend, or any else, no not upon his death-bed: only Dr. Boat discovered, that spiders, or something coming from them, were main ingredients of his *Pericardia*.

The sum
and conclu-
sion of the
point in
controversy.

AND indeed there are certain preparations and compositions of remedies so lucky, and whose success doth so much exceed expectation, and the efficacy of common compositions; that the same physician, whose they are, may upon several occasions prescribe an hundred others, each of which he may think as rational as any of those, which nevertheless shall be all of them much inferiour thereunto. And therefore I wonder not, that the most learned of the methodists themselves have much valued and celebrated some peculiar processes and receipts, as here amongst us (to mention no others) the famous Sir *Theodore Mayerne* was wont almost in all obstructions, cachexies, and hydropical distempers, to magnify and use that peculiar salt of steel of his, which he was pleased to call *Anima hepatis*.

AND to these domestick instances (which I might easily accumulate) of the esteem eminent physicians have made of receipts, I might add very many foreign ones. Nay, *Galen* himself, who has so copiously treated of the *Materia medica*, and the composition of medicaments, though he were sufficiently expert at drawing up receipts, doth yet in his book *de compositione medicamentorum*, and elsewhere, transcribe, and sometimes commend (and mention his having used) divers of the compositions of ancients physicians, and especially magnifies *Andromachus* his treacle.

I MIGHT, *Pyrophilus*, here mind you, that we see, that chymistry, as incomplete as yet it is, has been able so much to improve the preparation of remedies, as to afford us some, which are so innocent as well as efficacious, that in the diseases they principally respect, they require not, as of necessity, near so much of theoretical skill, as others do in the administer. I might likewise take notice, that experience also teacheth, especially by what we see performed by the *Spaw*, and some other mineral waters, that one medicine may be so richly endowed, as to be more effectual against several differing diseases, than even the better sort of other remedies against any one particular disease.

I MIGHT further represent as something that makes yet more to my present purpose, that though every body can advise his sick friends to an air, that is famously healthful, if there be any within a convenient distance from them; yet there are some airs so eminently good, and that not upon the account of any one predominant quality, that makes them opposite to a disease springing from its contrary, but from a hidden temperature, or certain friendly effluvia, that they alone
often

often cure variety of diseases in persons of differing ages and complexions: as navigators observe in the Isle of *St. Helen*, where the Spaniards and some other Europeans, in their passage to the *Indies*, often leave without physicians great numbers of sick, whom they find for the most part recovered at their return. And that sometimes even the acutest diseases may by the sanative steams, that enrich the air, be cured almost in a trice, is assured by those, that have lived in *Grand Cairo*, who have affirmed to me, what the learned *Prosper Alpinus*, who so long practised physick there, assures us, that upon *Nilus's* beginning to overflow, though in the heat of summer, there ensueth a sudden recovery of those multitudes of persons of differing ages, temperatures, sexes, &c. which there happen at that time to lie sick of the plague. These things I say, *Pyrophilus*, and more I might add, to what you find dispersed here and there in the essays, which this paper accompanies, towards the inferring, that we should not hastily conclude it impossible, that there may be found such medicines, as may be more than particular and specifick remedies, without requiring the giver to be a great physician. But to draw at length to a conclusion, I shall rather sum up my present thoughts of this matter, thus.

ORDINARY receipts without an ordinary measure of skill in physick are not rashly to be relied on, especially in acute diseases; where, by giving medicines, otherwise innocent enough, to lose the opportunities of administering proper ones, may be very prejudicial; and where sometimes the several seasons of the diseases do require such differing remedies, if they be but ordinary ones, that a medicine proper enough for the disease at one season of it, may do mischief at another. But if indeed there be noble and extraordinary *Arcana*, that work rather by strengthening and restoring nature, and resolving, or otherwise destroying the peccant matter they find any where in the body, than by irritating and weakening nature, or putting her as it were to a troublesome plunge; the use of such remedies may deserve to be a little otherwise considered, as that, which may not ordinarily (for I say not ever) require more instruction than may be afforded to persons not indiscreet, by such directions and cautions as may be divulged, or otherwise communicated, together with the remedies themselves: as we sometimes see, that by the help of such instructions unlearned persons, and even old wives, do with some one sovereign plaster, balsam or other outward remedy, cure many and various tumours, ulcers, and other sores, in persons of differing sexes, ages, and complexions. And because you will easily grant, that this example does far less accommodate our present purpose than does the case it self, as I just now put it; I hope you will allow me to represent further, that at least it seems not so rational to judge of all the remedies, that art improving nature can afford us, by those, that are hitherto in use, either among methodists or vulgar chymists; but rather to think, that the nobleness of remedies will be advanced according as the art of preparing them shall be promoted; and that it is not so safe and easy, positively to determine the efficacy of the former, otherwise than in proportion to the discoveries we have attained to in the latter.

SOME
CONSIDERATIONS
TOUCHING THE
STYLE of the HOLY SCRIPTURES.

EXTRACTED

From several Parts of a DISCOURSE,
Concerning divers Particulars belonging to the BIBLE;
Written divers Years since to a FRIEND.

TO THE
EARL of ORRERY,
One of the LORDS JUSTICES of the KINGDOM of IRELAND,
LORD PRESIDENT of the PROVINCE of MUNSTER, &c.

MY DEAREST BROTHER,

THAT sacred book, which furnishes our preachers both with their texts and a great part of their discourses on them, being the subject, about which I am to entertain you, I presume it will not much surprize you, if what I shall say, in representing to you some considerations on that book, relish more of a sermon than of a letter of compliment. And indeed it would so little become a person, that writes of my subject, and with my design, to startle at the very beginning such readers, as he desires to find or make devout, with any thing written in the wonted strain of epistles dedicatory; and the nature of the treatise, to which this paper is premised, does allow so little of that, whereof custom, on such occasions, is wont to challenge so much; that I should let this book come forth undedicated, were it not that the motives, that induced me to address it to you, are of such a nature, that I hope, that merely by a plain representation of them I may comply with what makes me look upon this dedication as a duty, without departing from the serious design I proposed to my self in the dedicated book. Although then such readers, as having perused your writings, shall cast their eyes on mine, will, I fear, think it a bold presumption in me to address discourses, concerning a style, to a person so much and so justly applauded for his; yet as several reasons engage me to present you these thoughts, so the fear of passing for presumptuous for so doing obliges me to mention some of those reasons. Whereof the first shall be, that your kindness for, and your resemblance in many particulars to, *Theophilus*, makes me often fancy, that I am yet
entertaining

entertaining that rare person, when I write on the behalf of the scripture unto you. Who may also, I presume, remember (which is my second reason) that when, seven or eight years ago, I ventured to shew you divers of these papers, with others (that I yet suppress) belonging to the same treatise, you were pleased to give me such a permission, that in case they should ever be made publick, I might address what I had written at your friend's desire particularly to you, as I took for an engagement, if not a command. So that how unlike soever the following treatise is to that best of books it would recommend; yet since you have thus made the present address a duty, I must elect rather to betray to you my weaknesses, than not manifest my obedience. And to these I must subjoin this third consideration, (more prevalent perhaps with me than both the former) that (as a homely digger may shew a man a rich mine) whatever the book may be that I present you, that which I recommend to you is a matchless one; and will, if so discerning a reader shall bring as much assiduity as capacity to discover its prerogatives, appear so worthy of what I have said of it, that I allow my self a hope, the following considerations will prove so happy, as either to endear the scripture to you, or (by not appearing such as so good a subject would suggest to a good pen) invite you to substitute better in their rooms. And in either of these cases I shall not have cause to repent of having written them; since they will prove serviceable either to the book or to the man, to whom I most desire to be so. And this hope I must again own to be the chief inducement of my venturing to present a fragment of an unpolished treatise to a person, that is wont to write such as are so eloquent and accomplished in their kind. For though severe, and not incompetent, judges of compositions of this nature have been pleased to give these papers no disapproving character; yet since I present them to you, the chief thing I dare pretend to in them is only (as the singing rare songs ill is wont, by an unheeded indignation, to engage the possessors of rare voices to make them admired) by disclosing my zeal and insufficiencies, to invite you to rescue so excellent a theme as the scripture from so dull a pen as mine, by employing your happy one in its defence and celebration: or, (if your partiality should make you place any value on so unfinished a piece) to convince you how capable of rare thoughts my subject is, by its being able to furnish so barren a brain as mine with acceptable ones. And certainly, your pen having no less served your fame than either your sword, or your employments (how high soever;) it could not but bring the scripture more than a few of the most witty and illustrious votaries, if that eloquence were employed to enamour them of that divine book, that hath made them so generally in love with your celebrated *Parthenissa*. I will not represent to you so pious an exercise of your rhetorick and muse as a duty, for fear of lessening the disinterestedness of the employment I recommend to you, by implying, that you cannot decline it without a fault. I shall rather invite your pen to prefer itself to, and grace religious subjects, by assuring you, that as there are none more worthy of your pen, so there are few pens more likely to succeed upon some of them than yours. Those handsome essays your muse hath charmed me with upon some parts of the bible have given me longings equally great and just, to see her, by a devotedness to such heavenly themes, as happy in the choice of her subjects, as she is wont to be in the embellishing of them; and to have her make that her chief employment, wherein it is best to do, what she doth always, succeed well. And as with burning-glasses though we cannot make the sun shine, yet when he doth vouchsafe us his heavenly beams, we can, with those glasses, both increase light and heat, and carry and settle them here and there as we see cause: so though with wit and parts, their possessors could never have been able to engage God to send forth his light and his truth; yet now that revelation hath disclosed them, and now he hath been pleased to make them radiate in his heavenly

heavenly word, men may, with knowledge and eloquence, happily recollect those scattered divine beams, and uniting them in particular subjects, and kindling with them the topicks proper to warm and work on our affections, may powerfully illustrate truths, and enflame zeal. Towards the latter end of the ensuing papers you will find something said to persuade our *Theophilus*, that the choicest poetical and rhetorical ornaments may, without injury to their lustre, be employed about such subjects as may be chosen in the scripture: but more and better things, to the same purpose, have since been said by our ingenious friend Mr. *Cowley*, who not only has employed much eloquence to persuade that truth in his preface to his poems, but has in one of them given a noble example, and consequently a proof of it. I need not tell you, I mean his *Davideis*, a work and way of writing, which, since your muse has already thought fit to celebrate, I hope she will hereafter think fit to imitate. And this I wish the more earnestly, because it hath been observed, that secular persons of quality (of whom I have elsewhere occasion to name divers) are generally much successfuller in writing of religion, (to gentlemen especially) than scholasticks or men in orders; not only because their style and way of writing is observed to have in it some pleasing *je ne sçay quoy*, something of easy, genuine and handsome, that's peculiar to it, (differing from regular eloquence, as a good mien doth from beauty) and relishes of the native gracefulness wont to attend on what they do or say; but because their writings attract more readers by the authors conspicuousness, and make deeper impressions in them, by being supposed more disinterested, and looked upon, not as suggested by their profession or self-ends, but as the sincere dictates of their unbridled souls. For my part, though I am not so happy as to be much concerned in all the precedent considerations, yet those, that you will find, towards the end of the longest digression in the following discourse, have been so prevalent with me, that though some very fair and very persuasive persons (whom perhaps I need not name to you) did, when I was writing the annexed treatise, labour to divert my pen to some more youthful and more fashionable compositions, by flattering me with a persuasion, that in those attempts of that nature I had formerly occasion to make, I was not altogether unlucky; yet I, that would bring my self to prefer to a whole wood of bayes the least sprig of the tree of life, am inclined to think, that a Christian may possibly find a higher satisfaction in persuading men to pay praises to the scripture, than in receiving them from all the world besides; and would think it more desirable, (were the choice his) to discountenance prophane wit, than live unrivalled in the glory of it. And though, for my own particular, such a temper be, I fear, more my aim than my attainment; yet when I write of sacred subjects, I had rather a book of mine should resemble the moon, which, though she be but small, less elevated, and full of imperfections, lends yet a useful light to men, and produces here and there a motion that obeys a heavenly influence, than a star of the first magnitude, which though more high, more vast, and more flawless, shines only bright enough to make it self conspicuous. Pardon me therefore, my dearest brother, if my concern for religion and you have made me importunate in appearing so eagerly solicitous to see your applauded pen sanctified by, and adorn the best of subjects: to engage you to which, if the ensuing discourse may but be so fortunate as in any degree, or upon any score, to contribute any thing, I shall either not esteem it a trifle, or not regret the having written it. For it is not always so despicable a piece of service as may be imagined, to endear, by particular considerations, an excellent book, (and how much more that incomparable book the scripture?) to a person capable of discovering and making use of the rare things it contains. To which purpose I might offer you divers more serious instances, but shall only at present (a little to divert you) take this occasion to tell you, that *Ben. Johnson*, passionately com-

The Epistle Dedicatory.

plaining to a learned acquaintance of mine, that a man of the long robe, whom his wit had raised to great dignities and power, had refused to grant him some very valuable thing he had begged of him, concluded with saying, with an upbraiding tone and gesture to my friend; *Why, the ungrateful wretch knows very well, that before he came to preferment, I was the man, that made him relish* Horace.

BUT to return to the following book, though I hope you do not think me so vain as to doubt, that it is suffered to come abroad with imperfection enough to need my excuses and your pardon; yet since the treatise it self is so unmeasurably prolix (for a part of an essay) it were unfit the address of it should be so too; and give your patience as great an exercise upon the score of its quantity, as upon that of its quality. And therefore, referring you for what I might say of apologetical to what I say to the reader, I shall only add, that though, in *Epistles Dedicatory*, custom hath made it a kind of rudeness not to expatiate in praises, and conclude with complements; and though what you have acted, and what you have written, might supply a person less concerned than I with matter for a panegyric address; yet since I told you, at the beginning of this letter, I should rather preach than compliment in it, and since praises fit to be ascribed to my Lord *Orrery* would be unfit to be ascribed him by his brother; and since also it were scarce more uneasy for me to make you any other than seeming complements, than it were presumptuous to address any at all to so great a master in the art; I shall both decline praises, which not to seem flatteries, where you are not known, would perhaps be thought detractions where you are; and venture to conclude this letter, as I have begun and continued it, without compliment, upon the score of being without, if not above any.

My dearest Brother,

Your most Affectionate Brother,

and most Faithful Humble Servant,

ROBERT BOYLE.

To the READER.

The author having with the following discourse sent to the publisher a letter, which contains almost all the particulars that would be requisite to be taken notice of in a preface, it is thought fit to premise, instead of it, the letter itself, as it was addressed to Mr. P. P. A. G. F. I. (to favour whose modesty, he is not now more openly named).

SIR,

YOU will perhaps think it strange, that a person obsequious enough to those he loves should be able to hold out so long against the importunity of two such powerful solicitors, as my willingness to own a veneration for the scripture, and my unwillingness to deny you any thing. But if you will give me leave to acquaint you with the considerations, that have hitherto dissuaded me from the publication of the papers you press for, you will, I presume, rather marvel at my resolving at last to comply with your desires, than that I have been somewhat long contesting, before I could take up so opposed a resolution. First then, the treatise, of which the papers you desire make a part, was written nine or ten years ago, when my green youth made me very unripe for a task of that nature; whose difficulty requires, as well as its worth deserves, that it should be handled by a person, in whom nature, education, and time have happily matched a senile maturity of judgment with a youthful vigour of fancy. Next, the discourse I have mentioned being written to a private friend, who put me upon that task, I not only had a theme of another's choosing imposed upon me, for which he was pleased to think me much more fit than I had reason to think myself, but was by the freedom allowable among friends tempted to vent and express my thoughts with more negligence, than were proper to be made use of in a solemn discourse intended for publick view. The contrary of which were yet very requisite for a person, who though he have, by I know not what unhappy fate, been cast upon the learning divers languages, has yet too great a concern for the knowledge of things to be a diligent or solicitous considerer of words; and so was more fit to write almost of any thing, than of a style, or of matters rhetorical. Besides, that my Essay touching the Scripture having not been all written in one country, but partly in *England*, partly in another kingdom, and partly too on shipboard, it were strange, if in what I writ, there did not appear much of unevenness, and if it did not betray the uneasiness, and relish of the unsettledness of the wandering author, who, by thus rambling, was reduced, for want of a library, to comply with the request of his friend, who was more desirous to receive from the author apples and pears growing in his own orchard, than oranges and lemons fetched from foreign parts: whereby I was condemned not to enrich my discourse with what I might have borrowed, of real and valuable, from the eloquent composures of more happy pens. But these, Sir, are not all the determents, that opposed my obeying you; for besides these disadvantages, with which the discourse itself was written, that part of it you demand must appear with peculiar as well as great disadvantage: for in an intire and continued discourse, the several parts, that compose it, do mutually afford light and confirmation to each other. And therefore, though whatsoever I here present you, touching the style of the scripture, had been written altogether in some one place of the discourse, whereof it makes a part; yet I could not dismember it from the rest, without a great deal of injury, as well to it as to the rest of the treatise.

K k 2

But

But this is not the worst of my case; for though I did, in one part of my essay of the scripture, more professedly apply myself to the consideration of its style; yet, because divers things were interwoven even in the distinct part, which were not so fit for publick view; and because that in divers of the other parts of my essay I had here and there, frequently enough, occasion to say something of the same theme, I have been obliged, that I might obey you, not only to dismember, but to mangle the treatise you perused, cutting out with a pair of scissars here a whole side, there half, and in another place perhaps, a quarter of one; as I found, in the other parts of my discourse, longer or shorter passages, that appeared to relate to the style of the scripture, that I might give you at once all those parts of my essay, which seemed to concern that subject. And though I have, here and there, by dictating to an amanuensis, inserted some lines or words, to make the loose papers less incoherent, where I thought it easy to be done; yet in many others I have only prefixed a short black line to the incoherent passages, if I found they could not be connected with those, whereunto I have joined them, without such circumlocution, as either the narrowness of the paper would not permit, or my present distractions (which you know are not a few) and the weakness of my eyes, would not allow of. For to compleat my unfitness to obey you with any thing of accurateness, I must, to obey you at all, do it, both when I have other composures in the press, and when the distemper in my eyes makes me so far from daring to transcribe the papers I send you, that I might alter them, according to the exigency of your design in them, that I durst not so much as read them over, but with another's eyes. To which I must add, that, besides all these disadvantages I have already mentioned, I cannot but foretel, that the following discourse may prove obnoxious to the censures of differing sort of readers, and particularly to those of courtiers, for too neglected, and those of critics, for too spruce a dress. By all which, I presume, you will be easily induced to believe, with me, that I cannot expose the papers you desire so much to their disadvantage, and my own, without some exercise of self-denial; since, without needing much foresight, I may well apprehend, that I shall hereby hazard the loss of the most part of whatever little reputation, in this nature, any of my former moral or devout composures may, among favourable readers, have procured me.

BUT, by this time, Sir, I suppose not only, that you have left wondering at my making some difficulty to put the annexed papers into your hands, but that I owe you, and my other friends, an account, why I now consent to a compliance with desires, which such powerful considerations would dissuade my assenting to.

My first inducement then to what I do, is the favourable character, that you and some other very competent judges have been pleased to give me of these papers; and especially your thereupon pressing their publication upon me as a duty, whereto I stand obliged, to those many readers, whom you would have me think likely to be benefited thereby. For in such cases, where knowing and sober persons think there is a great probability of a discourse's doing good, it is not impossible, but that an unwillingness to have it published may not proceed out of modesty, as from some secret pride, almost as unjustifiable, as if a physician should refuse to come abroad upon an urgent occasion, because he has not his best clothes on, or is not carefully dressed. And therefore, when I incline to make, with you, a case of conscience of the matter, I think myself obliged, whatever my private apprehensions may be of the success, to do my duty, and leave events to the wise and sovereign disposer of them. It is not, that I have the vanity to expect, that I should convert obstinate and resolved cavillers, nor much instruct the great clerks; but since I have not yet met with such a discourse, as I intended mine to be; and since the greater part of the things I have written in it

will

will not, perhaps, be elsewhere met with; I hope, that what I have said may not be useless to those, who have considered the subject, I treat of, less attentively than I have done, and may, if not procure a veneration for the scripture in those that are altogether indisposed to it, yet at least increase or confirm it in those, that have already entertained it; and furnish such devout persons with something to alledge on the scripture's behalf, who are better furnished with affections than with arguments for it. And I the less scruple to allow myself such a hope, because you have been pleased to make, not only to me, but to others, such a mention of, the following papers, that after your preference of them to the other pieces of devotion, you have yet seen of mine (without excepting that discourse of *Seraphick Love*, which yet has had the luck to be so favourably entertained by readers of all sorts) I shall confess to you, that as some of them do now appear very much dislocated and mangled, so others were penned with more care, than any other of my writings about matters theological. And indeed I conceived myself obliged, in point of gratitude as well as duty, to speak as advantageously as I could of the scripture; because, if I may without vanity make such an acknowledgement, I am sensible I have been benefited by it, and might have been much more so, if I had been as disposed to learn, as the matchless book is qualified to teach. And I confess to you also, that since the physiological writings I have been induced to publish of late, and the sort of studies, to which (for reasons to be told you at a fitter opportunity) I seem, at present, to be wholly addicted to, make many look upon me as a naturalist; and since some persons, as well philosophers as physicians, have either faultily, or at least indiscreetly, given many men occasion to think, that those, that being speculatively studious of nature's mysteries, depart, as I often do, from the vulgar peripatetick philosophy, and especially if they seem to favour that, which explicates the phenomena of nature by atoms, are inclined to atheism, or at least to an unconcernedness for any particular religion: Since, I say, these things are so, I was not unwilling to lay hold of this opportunity, to give a publick testimony, whereby such as do not know me may be satisfied, (for I presume, all that do know me, are so,) that, if I be a naturalist, it is possible to be so without being an atheist, or of kin to it; and that the study of the works of nature has not made me either disbelieve the author of them, or deny his providence, or so much as disesteem his word, which deserves our respect upon several accounts, and especially that of its being the grand instrument of conveying to us the truths and mysteries of the Christian religion; my embracing of which I know not why I should be ashamed to own, since I think I can, to a competent and unprepossessed judge, give a rational account of my so doing.

To all this, I might subjoin some apologies, which might perhaps serve to prevent, or withdraw, the censures of some sorts of readers.

For to critics and philologers I could represent, partly, that I have not a little impoverished my discourse, by making use of books, to shun the repetition of what I found obvious already; partly, that when I wrote the essay, of which the ensuing treatise is a piece, I had thoughts of annexing it to annotations, wherein I hoped to illustrate, and by particular instances to exemplify, divers of those things, which should appear to require it, or which else the readers might suspect I have slightly considered, because I seem to make but a transient mention of them; and partly, too, that I ignored not the stricter interpretations given by modern critics to divers texts by me alledged; but that (not having opportunity to criticize) I was content to use them in their received, or obvious sense; and have sometimes employed them but by way of allusion, or as arguments *ad hominem* (wherein some of my readers are like to acquiesce, though I do not) and sometimes rather used them to express, than

than prove my thoughts. And, indeed, in these popular discourses, which are not written for, nor to be examined as regular disputations, men use not so much to look whether every thing be a strict truth, as whether it be proper to persuade, or impress the truths they would inculcate; and especially in compositions of the nature of this of mine, men have been rarely censured for being sometimes even indulgent to the exigencies of their themes. Those, that require more of method than they will here find, may be advertised, that much of this scribble being designed to serve particular acquaintances of mine, it was fit it should insist on those points they were concerned in; and that (consequently) much of the seeming desultoriness of my method, and frequency of my rambling excursions, have been but intentional and charitable digressions out of my way, to bring some wandering friends into theirs, and may closely enough pursue my intentions, even when they seem most to deviate from my theme. And as for the longer excursions, which either you, or other judicious friends, would needs have me leave here and there, I have, for the ease of my perusers, annexed to them some marks, whereby they may be taken notice of, to be digressions; that as I submit to their judgment, who think they may be useful to some readers, so I may comply with my own unwillingness to let them be troublesome to others; who by this means have an opportunity to pass by, if they please, such, as they shall not expect to find themselves, (either upon their own score, or that of their acquaintances) concerned in. To those of the wits, who happening to be disregards of the scripture, may find themselves upon that account used here with any shew of slighting or asperity, I may add to what I have already said in the papers themselves, that it hath been, but as we pinch, and cast cold water on the faces of persons in a swoon, to bring them out of it to themselves again; I having done it with as harmless intentions, as those of the angel (mentioned in the *Acts*) when he struck *Peter* on the side, not to hurt him, but to awake him, lead him the way out of the prison he was bound in, and rescue from imminent death. And if that will not satisfy some of the least judicious, or the most desperate, (for others I expect to find better affected or more moderate) I am willing to leave the intelligent and pious to judge between us; assuring those, that are so much more jealous of their own honour than of God's, that as I writ to reclaim them, not to deprive them of the repute of wits, or share it with them, so I shall not overmuch deplore the being by them denied a title, to which I have as little pretension as right. And (to dispatch) I might add, that orators may not unjustly bear with some rudenesses in the style of a person, that professes not rhetorick, and writes of a subject, that needs few of her ornaments, and rejects many as indecencies misbecoming its majesty: and that severer divines may safely pardon some smoothness in a discourse, written chiefly for gentlemen, who would scarce be fond of truth in every dress, by a gentleman, who feared it might misbecome a person of his youth and quality studiously to decline a fashionable style. And if any divine would censure me for intruding upon his profession, and handling my subject less skilfully than he would have done; I will not urge, that to write well on this subject is a task, which he that shall try, will perhaps find far less easy than one would imagine; but I shall rather tell him, that I hope I may obtain his pardon, by assuring him, that I shall be as little angry to be rectified in my mistakes, as to be shown the way when I am out of it, and as little troubled to have this discourse, that but skinnishes with laziness and prophaneness, surpassed by another on the same subject, as to see another embracer of the same quarrel come in with a fresh regiment, to assist me against a formidable enemy, in a conflict I were engaged in but with a troop, or bring cannon against a fortress I had but sakers to batter with. Yes, I shall be glad, if my dim short-lived match but serve to light

Acts xii.
7, &c.

another's brighter torch; and shall think it a happiness to have contributed, though but thus occasionally, towards the elucidation, or splendour of the scripture. And consonantly to this temper, I would beseech any reader, that may so much want learning as to need such a request, not to measure what can be said in the defence and celebration of the scripture's style, by what hath in the following discourse been traced by the callow pen of a travelling layman. For I profess ingenuously, that there can as little be an unwelcomer as an unjust compliment placed upon me, than to mistake any thing that I am able to say, and much less what I have said, for the best that can be said upon such a subject. Nor is it my least encouragement to consent to the publication of such incomplete writings, that the considerations already intimated will probably keep my readers from doing the scripture and their own judgment so great an injury.

BUT I see I have so far transgressed the bounds of a letter, that if I add any thing more of apology, it must be for having been so prolix already. Wherefore there scarce remains any thing for me, but to mind you, that since your persuasions have much contributed to my exposing the following tract, incomplete as it is, your own credit is somewhat concerned in it as well as mine. And therefore I hope you will have a care, that there be no faults of the printer added to those of the author, which do so little need additional blemishes; and especially that there pass no mistakes of the punctuation. For in such composures as this, if the stops be omitted, or misplaced, it does not only lessen the gracefulness of what is said, but oftentimes quite spoil the sense. And if by this care of yours (which your affection, both for the subject, and the writer makes me confident of) and by the authority of your approbation, I find these imperfect considerations to be so favourably received as to deserve another edition; it will perhaps invite me to put them forth enlarged, and recruited with what I may meet with pertinent to this subject in such other papers of mine concerning the scripture, as I had not yet the conveniency to get into mine own hands and look over. However, though I pretend not here to answer all objections against the style of the scripture; yet as I hope, I have been so happy as to answer some of them, and weaken most of the rest; so if others, that are more able, will but employ themselves as earnestly in so useful a work, there is great hope, that some answering this objection, another that, and a third another, they may at length be all of them satisfactorily replied to. And in the mean time I shall think my labour richly recompensed, if they either procure or establish a veneration for the scripture in any of my readers; or do at least encourage those, that are qualified for a far more prosperous making such an attempt, to undertake it, by showing those of them that know me, what were easy for them to do, whilst they see what has been done even by me; whom sure they will not think to be half so much an orator, as I hope so uneasy a proof of his obedience will make you think him,

Sir, Your Affectionate Friend

and humble Servant,

ROBERT BOYLE.

SOME
CONSIDERATIONS
TOUCHING THE
STYLE of the HOLY SCRIPTURES.

THESE things, dear *Theophilus*, being thus dispatched, I suppose we may now seasonably proceed to consider the style of the scripture: a subject, that will as well require as deserve some time and much attention; in regard that divers witty men, who freely acknowledge the authority of the scripture, take exceptions at its style, and by those and their own reputation divert many from studying, or so much as perusing, those sacred writings; thereby at once giving men injurious and irreverent thoughts of it, and diverting them from allowing the scripture the best way of justifying it self, and disabusing them. Than which scarce any thing can be more prejudicial to a book, that needs but to be sufficiently understood to be highly venerated; the writings these men criminate, and would keep others from reading, being like that honey, which *Saul's* rash adjuration with-held the Israelites from eating, which being tasted, not only gratified the taste, but enlightened the eyes.

1 Sam. xiv.
ver. 27, 29.

Now these allegations against the scripture we are to examine being but too various, it will be requisite for us to consider the style of it, not in the stricter acceptation, wherein an author's style is wont to signify the choice and disposition of his words, but in that larger sense, wherein the word style comprehends not only the phraseology, the tropes and figures made use of by a writer, but his method, his lofty or humbler character (as orators speak) his pathetical or languid, his close or incoherent way of writing; and in a word, almost all the whole manner of an author's expressing himself.

WHEREFORE, though the title of an essay prefixed to this treatise will, I presume, invite you to expect from me rather some loose considerations than any full and methodical discourse concerning the style of the scripture; yet I hope you will not think it strange, if so comprehensive a theme make this part of the essay disproportionate to the others; especially since the nature of your commands, and that of my design, oblige me to interweave some other things with those that more directly regard the style of the scripture, and particularly to lay hold on all opportunities I can discreetly take, to invite you to study much, and highly to esteem a book, which there is no danger you can too much study, or esteem too highly.

It has been a common saying among the ancients, that even *Jupiter* could not please all. But by the objections I meet with against the scripture, I find, that the true God himself is not free from the imputation of his audacious creatures, who impiously presume to quarrel as well with his revelations as his providence, and express no more reverence to what he hath dictated than to what he doth. For not now to mention what is by atheists and antiscripturists alledged to overthrow the truth and authority of the scripture, (because it is not here, but elsewhere, that we are to deal with that sort of men) even by some of those, that acknowledge both,

(for with such only we have now to reason) there are I know not how many faults found with the style of the scripture. For some of them are pleased to say, that book is too obscure; others, that it is immethodical; others, that it is contradictory to itself; others, that the neighbouring parts of it are incoherent; others, that it is unadorned; others, that it is flat and unaffecting; others, that it abounds with things, that are either trivial or impertinent, and also with useless repetitions. And indeed so many and so various are the faults and imperfections imputed by these men to the scripture, that my wonder at them would be almost as great as is my trouble, if I did not consider, how much it is the interest of the great adversary of mankind, and especially of (that choicest part of it) the church, to depreciate compositions, that if duly revered would prove so destructive to his kingdom and designs; and if I did not also remember, that (such is the querulous and exceptionous nature of men) it was *Cicero* himself that observed, *Vitari non posse reprehensionem, nisi nihil scribendo*. But as poets and astronomers have fancied, among the celestial lights, that adorn the firmament, bears, bulls, goats, dogs, scorpions, and other beasts; so our adversaries impute I know not what imaginary deformities to a book, ennobled by its author with many celestious lights, fit to instruct the world, and discover to them the ways of truth and blessedness. Although, I say, this be so, yet since the misrepresentation made by these men of the Bible is not inferiour to that made by poets and cosmographers of the firmament; I hope you will be as little deterred by the most disparaging imputations from studying the scripture, as pilots are by the name of *bear* given to the most northern constellation, from having their eyes upon the pole-star, and steering their courses by it.

AND since you will easily believe, that a person so averse from wrangling as I, is not like to make the disputing with these censures of the scripture-style, any further his design, than as the invalidating their objections conduces to the reputation of that sacred book; I presume you will not think it at all impertinent, if oftentimes I intermix with those things, that more directly regard such objections, other things, that seem to tend rather to celebrate than vindicate the scripture. For in so doing, I hope I shall not alone considerably, though not perhaps so directly, strengthen my answers, by shewing that we justly ascribe to the scripture qualities quite opposite to the imperfections imputed to it; but I shall perfectly comply with my main design, which I here declare, once for all, is but to engage you to study and value the scripture, and therefore obliges me to answer objections only so far forth, as they may look like arguments to dissuade you from prizing and studying it. And because I find not, that the objections to be considered have any great coherence with, or dependence on each other, I shall not scruple to mention them, and my reflections on them, in no other order, than that wherein they shall chance to occur to my thoughts whilst I am writing.

OF the considerations then, that I am to lay before you, there are three or four, which are of a more general nature; and therefore being such as may each of them be pertinently employed against several of the exceptions taken at the scripture's style, it will not be inconvenient to mention them before the rest.

AND, in the first place, it should be considered, that those cavillers at the style of the scripture, that you, and I have hitherto met with, do (for want of skill in the original) especially in the Hebrew, judge of it by the translations, wherein alone they read it. Now scarce any but a linguist will imagine, how much a book may lose of its elegance, by being read in another tongue than that it was written in; especially if the languages, from which, and into which, the version is made, be so very differing, as are those of the eastern and these western parts of the world. But

of this I foresee an occasion of saying something hereafter; yet at present I must observe to you, that the style of the scripture is much more disadvantaged, than that of other books, by being judged of by translations. For the religious and just veneration, that the interpreters of the Bible have had for that sacred book, has made them, in most places, render the Hebrew and Greek passages so scrupulously word for word, that for fear of not keeping close enough to the sense, they usually care not how much they lose of the eloquence of the passages they translate. So that, whereas in those versions of other books, that are made by good linguists, the interpreters are wont to take the liberty to recede from the author's words, and also substitute other phrases instead of his, that they may express his meaning, without injuring his reputation; in translating the Old Testament, interpreters have not put Hebrew phrases into Latin or English phrases, but only into Latin or English words; and have too often besides, by not sufficiently understanding, or at least considering, the various significations of words, particles, and tenses in the holy tongue, made many things appear less coherent, or less rational, or less considerable, which, by a more free and skilful rendering of the original, would not be blemished by any appearance of such imperfection. And though this fault of interpreters be pardonable enough in them, as carrying much of its excuse in its cause; yet it cannot but much derogate from the scripture, to appear with peculiar disadvantages, besides those many, that are common to almost all books, by being translated.

For whereas the figures of rhetoric are wont, by orators, to be reduced to two comprehensive sorts; and one of those does so depend upon the sound and placing of the words (whence the Greek rhetoricians call such figures σχήματα λέξεως) that, if they be altered, though the sense be retained, the figure may vanish; this sort of figures, I say, which comprizes those that orators call *Epanados*, *Antanaclassis*, and a multitude of others, are wont to be lost in such literal translations as are ours of the Bible, as I could easily show by many instances, if I thought it requisite.

BESIDES, there are in Hebrew, as in other languages, certain appropriated graces, and a peculiar emphasis belonging to some expressions, which must necessarily be impaired by any translation, and are but too often quite lost in those, that adhere too scrupulously to the words of the original. And, as in a lovely face, though a painter may well enough express the cheeks, and the nose, and lips; yet there is often something of splendour and vivacity in the eyes, which no pencil can reach to equal: so, in some choice composures, though a skilful interpreter may happily enough render into his own language a great part of what he translates, yet there may well be some shining passages, some sparkling and emphatical expressions, that he cannot possibly represent to the life. And this consideration is more applicable to the Bible and its translations, than to other books, for two particular reasons.

For first, it is more difficult to translate the Hebrew of the Old Testament, than if that book were written in Syriack, or Arabick, or some such other eastern language. Not that the holy tongue is much more difficult to be learned than others; but because in the other learned tongues, we know there are commonly variety of books extant, whereby we may learn the various significations of the words and phrases; whereas the pure Hebrew being unhappily lost, except so much of it as remains in the Old Testament; out of whose books alone we can but very imperfectly frame a dictionary and a language; there are many words, especially the ἀπὸ λεγόμενα, and those that occur but seldom, of which we know but that one signification, or those few acceptations, wherein we find it used in those texts, that we

think we clearly understand. Whereas, if we consider the nature of the primitive tongue, whose words being not numerous, are most of them equivocal enough, and do many of them abound with strangely different meanings; and if we consider too, how likely it is, that the numerous conquests of *David*, and the wisdom, prosperity, fleets, and various commences of his son *Solomon*, did both enrich and spread the Hebrew language, it cannot but seem very probable, that the same word or phrase may have had divers other significations, than interpreters have taken notice of, or we are now aware of: since we find in the Chaldee, Syriack, Arabick, and other eastern tongues, that the Hebrew words and phrases (a little varied, according to the nature of those dialects) have other, and oftentimes, very different significations, besides those, that the modern interpreters of the Bible have ascribed to them. I say, the modern, because the ancient versions before, or not long after our Saviour's time, and especially that which we vulgarly call the Septuagint's, do frequently favour our conjecture, by rendering Hebrew words and phrases to senses very distant from those more received significations in our texts; when there appears no other so probable reason of their so rendering them, as their believing them capable of significations differing enough from those, to which our later interpreters have thought fit to confine themselves. The use, that I would make of this consideration, may easily be conjectured, namely, that it is probable, that many of those texts, whose expressions, as they are rendered in our translations, seem flat, or improper, or incoherent with the context, would appear much otherwise, if we were acquainted with all the significations of words and phrases, that were known in the times, when the Hebrew language flourished, and the sacred books were written; it being very likely, that among those various significations, some one or other would afford a better sense, and a more significant and sinewy expression, than we meet with in our translations; and perhaps would make such passages, as seem flat or uncouth, appear eloquent and emphatical. Whilst I am writing this, our English tongue presents to my thoughts an example, which may seem to illustrate much of the foregoing consideration: and it is this; that though, as one would easily believe, there are but a few forms of speaking, which relate to the birth of infants, yet there are five or six expressions concerning that one affair, wherein very peculiar and unwonted notions belong to the words and phrases: for, if I say, that such a woman has looked every hour these ten days; that yesterday she cried out; that she had a quick and easy labour; that last night she was brought-to-bed; that now she lies-in; and, that it is fit we should remember the lady in the straw: if, I say, I make use of any or all of these expressions, an Englishman would readily understand me; but if I should literally, and word for word, translate them, I say, not into Greek or Hebrew, but into the languages of our neighbour-nations, French or Italian, men would not understand what I mean. And if a discourse, wherein they were employed, were translated by an interpreter only acquainted with the genuine and more obvious signification of the English word, it would, in such passages, appear very disadvantageously, and perhaps be thought impertinent, or nonsensical, to a French or Italian reader.

BUT this is not all; for I consider in the second place, that not only we have lost divers of the significations of many of the Hebrew words and phrases, but that we have also lost the means of acquainting ourselves with a multitude of particulars relating to the topography, history, rites, opinions, fashions, customs, &c. of the ancient Jews and neighbouring nations, without the knowledge of which we cannot, in the perusing of books of such antiquity, as those of the Old Testament, and written by and (principally) for Jews; we cannot, I say, but lose very much of

that esteem, delight, and relish, with which we should read very many passages, if we discerned the references and allusions, that are made in them to those stories, proverbs, opinions, &c. to which such passages may well be supposed to relate. And this conjecture will not, I presume, appear irrational, if you but consider, how many of the handsomest passages in *Juvenal*, *Perfius*, *Martial*, and divers other Latin writers, (not to mention *Hesiod*, *Museus*, or other antienter Greeks) are lost to such readers, as are unacquainted with the Roman customs, government, and story; nay, or are not sufficiently informed of a great many particular circumstances, relating to the condition of those times, and of divers particular persons pointed at in those poems. And therefore it is, that the latter critics have been fain to write comments, or at least notes, upon every page, and in some pages upon almost every line of those books, to enable the reader to discern the eloquence, and relish the wit of the author. And if such dilucidations be necessary to make us value writings, that treat of familiar and secular affairs, and were written in an European language, and in times and countries much nearer to ours; how much do you think we must lose of the elegance of the book of *Job*, the Psalms of *David*, the Song of *Solomon*, and other sacred composures, which not only treat oftentimes of sublime and supernatural mysteries, but were written in very remote regions so many ages ago, amidst circumstances, to most of which we cannot but be great strangers? And thus much for my first general consideration.

My second is this, That we should carefully distinguish betwixt what the scripture itself says, and what is only said in the scripture. For we must not look upon the Bible as an oration of God to men, or as a body of laws, like our English statute book, wherein it is the legislator, that all the way speaks to the people; but as a collection of composures of very differing sorts, and written at very distant times; and of such composures, that though the holy men of God (as *St. Peter* calls them) were acted by the Holy Spirit, who both excited and assisted them in penning the scripture, yet there are many others, besides the author and the penmen, introduced speaking there. For besides the books of *Joshua*, *Judges*, *Samuel*, *Kings*, *Chronicles*, the four evangelists; the *Acts of the Apostles*, and other parts of scripture that are evidently historical, and wont to be so called; there are, in the other books, many passages, that deserve the same name, and many others, wherein, though they be not meer narratives of things done, many sayings and expressions are recorded, that either belong not to the author of the scripture, or must be looked upon as such, wherein his secretaries personate others. So that, in a considerable part of the scripture, not only prophets, and kings, and priests being introduced speaking, but soldiers, shepherds, and women, and such other sorts of persons, from whom witty or eloquent things are not (especially when they speak *ex tempore*) to be expected, it would be very injurious to impute to the scripture any want of eloquence, that may be noted in the expressions of others, than its author. For though, not only in romances, but in many of those that pass for true histories, the supposed speakers may be observed to talk as well as the historian; yet that is, but either because the men so introduced were ambassadors, orators, generals, or other eminent men for parts, as well as employments; or because the historian does, as it often happens, give himself the liberty to make speeches for them, and does not set down indeed what they said, but what he thought fit that such persons, on such occasions, should have said. Whereas the pen-men of the scripture, as one of them truly professes, having not followed cunningly devised fables in what they have written, have faithfully set down the sayings, as well as actions, they record, without making them rather congruous to the conditions of the speakers, than to the laws of truth.

Nor is it only the style of very many passages of scripture, that may be justified by our second consideration; but, with the same distinction well applied, we may silence some of their malicious cavils, who accuse the scripture of teaching vice by the ungodly sayings and examples, that are here and there to be met with in it. But, as the Apostle said, that *they are not all Israel, that are of Israel*; so we may say, that is not scripture, that is in the scripture: for many wicked persons, and their perverter Satan, are there introduced, whose sayings the Holy Ghost doth not adopt, but barely registers; nor does the scripture affirm, that what they said was true, but that it is true they said it. And if I had not reduced some of those cavillers to confess, that they never did themselves read those pieces of the Bible, at some of whose passages they cavil, I should much more admire than I do, to find them father, as confidently as they do all they hear cited from it, upon the enditer of it; as if the devil's speeches were not recorded there, and as if it were requisite to make a history divinely inspired, that all the blasphemies and crimes it registers should be so too. As for the ills recorded in the scripture, besides that wicked persons were necessary to exercise God's children, and illustrate his providence; and, besides the allegations commonly made on that subject, we may consider, that there being many things to be declined, as well as practised, 'twas fit we should be taught as well what to avoid, as what to imitate; and the known rocks and shelves do as well guide the seamen, as the pole-star. Now, as we could not be armed against the tempter's methods, if we ignored them, so could we never safer nor better learn them, than in his book, who can alone discover the wiles, and fathom the *depths of Satan*, and track him through all his windings, and (otherwise untraceable) labyrinths; and in that book, where the antidote is exhibited with the poison, and either mens defeat or victory may teach us, at others costs, and without our hazard, the true art of what warfare we are all so highly concerned in. And, as chymists observe in the book of nature, that those simples, that wear the figure or resemblance (by them termed signature) of a distempered part, are medicinal for that part of that infirmity, whose signature they bear; so, in God's other book, the vicious persons there mentioned still prove, under some notion, or upon some score or other, antidotal against the vices notorious in them, being (to present it you also in a scripture simile) like the brazen serpent in the wilderness, set up to cure the poison infused by those they resemble. *Whatsoever things were written afore-time*, says the Apostle, *were written for our instruction*. And, to make further use of our former comparison, those, to whom the scripture gives the names of lions, wolves, foxes, and other brutes, by God's assistance, prove to his saints as instructive beasts, as doth the northern bear unto the wandering pilot. And, as antiently God fed his servant *Elias*, sometimes by an angel, sometimes by a woman, and sometimes too by ravens, so doth he make all persons in the Bible, whether good, or bad, or indifferent, supply his servants with that instruction, which is the aliment of virtue, and of souls, and makes them and their examples contribute to the verification of that passage of *St. Paul*, wherein he says, that *all things co-operate for good to them that love God*.

Rom. ix.
6.

Rev. ix.
24.

Rom. xv.
4.

Rom. viii.
28.

My third consideration is this: That the several books of the Bible were written chiefly and primarily to those, to whom they were first addressed, and to their contemporaries; and that yet the Bible not being written for one age of people only, but for the whole people of God, consisting of persons of all ages, nations, sexes, complexions and conditions, it was fit it should be written in such a way, as that none of all these might be quite excluded from the advantages designed them in it. Therefore were these sacred books so wisely, as well as graciously, tempered, that their variety so comprehends the several abilities and dispositions of men, that (as some pictures

2 Sam. xii.
v.

pictures seem to have their eyes directly fixed on every one that looks on them, from what part soever of the room he eyes them) there is scarce any frame of spirit a man can be of, or any condition he can be in, to which some passage of scripture is not as patly applicable, as if it were meant for him, or said to him as *Nathan* once did to *David*, *Thou art the man*. What has been thus observed touching God's design in the contrivance of the scripture, may assist us to defend the style of a great multitude of its texts, and particularly of divers of those, which belong to the five following kinds.

AND first, the several books, that make up the canon of the Scripture, being primarily designed for their use, that lived in the times wherein they were divulged, it need be no wonder, if each of them contain many things, that principally concern the persons that then lived, and be accordingly written in such a way that many of its passages allude, and otherwise relate to particular times, places, persons, customs, opinions, stories, &c. which, by our formerly-mentioned want of a good account of such remote ages and regions, cannot afford us that instruction and satisfaction, that those, to whom such books were immediately addressed, might easily derive from the perusal of them.

NEXT, as some portions of scripture were principally designed for ages very long since past, so some other parts of it, especially those that are yet prophetick, may probably respect future times, much more than ours: and our posterity may admire what we cannot now relish, because we do not yet understand it. Moreover, there being many portions of scripture, as almost the whole four last books of *Moses*, wherein God is introduced as either immediately, or mediately giving laws to his people, or his worshippers, I suppose it will not be thought necessary, that such parts of scripture should be eloquently written, and that the supreme legislator of the world, who reckons the greatest kings amongst his subjects, should, in giving laws, tie himself to those of rhetoric; the scrupulous observation of which would much derogate from those two qualities, so considerable in laws, clearness and majesty.

1 Pet. i.
32.

BESIDES, there being a sort of men, of which I hope the number will daily encrease, who have such a desire, as *St. Peter* tells us the angels themselves cherish, to look into the mysteries of religion, and are qualified with elevated and comprehensive intellects, to apprehend them in some measure; it is not unfit, that to exercise such mens abilities, and to reward their industry, there should be some abstruse texts of scripture fitted to the capacities of such speculative wits, and above the reach of vulgar apprehensions.

Ezek.
xviii. 4.

AND, on the other side, the omniscient Author of the scripture foreseeing, that it would follow from the condition of mankind, that the greatest part of the members of the church would be no great clerks, and many of them very weak or illiterate, it was but suitable to his goodness, that a great many other passages of the books designed for them, as well as others, should be written in such a plain and familiar way, as may besit such readers, and let them see, that they were not forgotten, or overlooked by him, who truly says, by the prophet, that *all souls are his*. And yet in many, even of these texts, which seem chiefly to have been designed to teach the simple, scholars themselves may find much to learn. For not only there are some passages, that contain milk for babes, and others, that exhibit strong meat for riper stomachs, but oftentimes (as cows afford both milk and beef) the same texts, that babes may suck milk from, strong men may find strong meat in: the scripture itself in some sense fulfilling the promise made us in it, that *Habenti dabitur (to him that hath shall be given)* and being like a fire, that serves most men but to warm, and dry

dry themselves, and dress their meat, but serves the skilful chymist to draw quint-
essences and make extracts.

I DOUBT not but you are acquainted as well as I with divers querulous readers, who
very boldly find fault with this variety, wherein God hath thought fit to exhibit his
truth, and declare his will in holy writ, and presume to censure some texts as too
mysterious, very many as too plain. But these exceptions at the oeconomy of the
scripture do commonly proceed from their pride, that make them; for that vice, in-
clining them to fancy, that the Bible either was or ought to have been written pur-
posely for them, prompts them to make exceptions suitable to such a presumption;
and, whilst they look upon their own abilities as the measure of all discourses, to call
all that transcends their apprehensions, dark, and all that equals it not, trivial.
They will be always finding fault with the Holy Ghost's expressions, both where his
condescensions make them clear, and where the sublimity of the matter leaves them
obscurer; like bats, whose tender eyes love neither day nor night, and are only pleased
with (what is alone proportioned to their weak sight) a twilight, that is both or
neither. But as a skilful fowler (and the comparison will be excused by those, that
remember that God in scripture is said to be pressed as a *cart is pressed that is full of*
sheaves, and the son of man to be as *a thief in the night*) according to the differing
natures of his game, so contrives and appropriates his stratagems, that some he
catches with light, (as larks with day-nets) some with baits, (as pigeons with peas)
some with frights, (as black-birds with a sparrow-hawk or low-bell) and some he
draws in with company (as ducks and such like social birds with decoy-fowl): so God
knowing that some persons must be wrought upon by reason, others allured by interest,
some driven in by terrour, and others again brought in by imitation, hath by a rare and
merciful (if I may so call it) suppleness of wisdom so varied the heavenly doctrine into
ratiocinations, mysteries, promises, threats and examples, that there is not any sort of
people, that in the scripture may not find religion represented in that form they are
most disposed to receive impressions from; God therein graciously dealing with his
children not unlike the prophet, that shrunk himself into the proportion of the child
he meant to revive. The genius's, the capacities and the dispositions of men are so
distinct, and oftentimes so extravagant, that there is scarce a passage of scripture, that
is not suitable or appropriate to some of those numberless differences of humour the
Bible was designed for; and in that unimaginable variety of occurrences shared
amongst such vast multitudes, finds not a proper object. And therefore God, who
(having created them) best knows the frame of mens spirits, having been pleased to
match them with proper texts; I shall not quarrel with his vouchsafing to lift myste-
ries to those, that would be deterred by any other way of expressing them, and to
qualify his instruments according to the natures he designs them to work upon, lest he
should say to me with the house-holder in the gospel, *Is thine eye evil, because I am*
good? And sure it must extremely misbecome us to repine at the greatness of God's
condescensions, only upon the score of a knowledge or attainments that we owe to it.

Amos xi. 15.

2 Kings iv.
34.

By reflecting upon the three foregoing general considerations, you will, I presume,
easily perceive, what it is that is pretended to in what I represent to you in the behalf
of the scripture. For you will easily guess, by what I have hitherto told you, I pre-
tend not to prove or assert, that every text of scripture, especially in translations, is
embellished with the ornaments of rhetorick, but only to shew these two things; the
one, that as there may be drawn from divers things in the scripture it self (without
excluding the style) considerable arguments of its having been written or approved
by men peculiarly assisted by the spirit of God; so if a man be persuaded either by
these intrinsick arguments, (which I may in another paper evince to be no slight ones)

OR

or by any others, of the heavenly origination of the scripture; if, I say, a man be persuaded of this, he ought not in reason by the style of these books to be kept from diligently studying of them, and highly valuing them. The other (which I add as one evincement of the former) is, that not only the scripture is every where written with as much eloquence as the chief author (whose omniscience qualified him to judge best in the case) thought fit and expedient, as we now have the sacred books, especially in their originals, very many passages of them are so far from being destitute of what even our western nations count eloquence, that they deserve to be admired for it. And, *Theophilus*, if you please to keep in your eye what I have now told you concerning my scope in writing, and to bear in your memory the three general considerations I have premised, I shall need hereafter, as often as I have occasion to mention them, only to point at them; and thereby shall excuse you and my self from the unwelcome trouble of many times repeating the same things.

To proceed then to the more particular objections against the scripture, the first I shall consider is, that it is obscure. And this I find alledged by two sort of men to two differing purposes; some endeavouring by it to disgrace the Bible, and others only making the pretended darkness of many of its passages an excuse for their not studying it.

To the first sort of objectors I answer, that it is little less than inevitable, that many passages of the scripture should seem obscure to us, and that it is but fit, that divers others should be so too.

For first, the objectors, as I formerly observed, reading the Bible but in translations, are destitute of those helps to understand the sense of many passages, that may be afforded by skill in the original languages. Besides, that even to those, that have taken pains to understand the original tongues, the genuine sense of divers words and phrases is denied by the injury of time, through which (as was already noted) a great part of the Hebrew and Chaldean tongues have been lost.

2dly, MANY texts appear obscure to those, that live in these latter times, only because that by reason of the perishing of those writings and other monuments of antiquity, that were contemporary to the books of the old testament, we cannot be sufficiently acquainted with the history, the laws and customs of the *Jews*, and other nations mentioned in the scripture; so that it need be no wonder if divers passages of the books of *Genesis*, *Josuah*, *Judges*, *Samuel*, the *Kings*, *Hester*, and other historical books of the scripture, as also of the four last books of *Moses*, are obscure to us; and yet might be very intelligible to those, in whose times they were written, and for whose use they were principally designed. As although *Lucius Florus* would in many places appear very obscure to such readers, as know nothing of the Roman affairs, but by the account given of them in his writing, (whence divers late critics have been invited to illustrate him out of other Latin authors) yet questionless to the Roman readers, that lived in his time, or not very long after, his book was easy enough to be understood. How much the want of other historians, contemporary to the penmen of the old testament, may make things seem obscure, that might by such stories be easily cleared up, we may observe from divers passages of the new testament, which can scarce be well understood without an account of *Herod's* family, and the changes that happened about our Saviour's time in *Judaea*, which was sometimes all of it governed by *Herod* the great, that massacred the children of *Bethlehem*, and sometimes was governed by *Pilate* and other Roman magistrates; and sometimes was so divided, that it was as to some parts only governed by *Herod's* descendants under various titles; the want of the knowledge of which, and of the several princes that bore the name of *Herod*, does much puzzle many readers, that are strangers to *Josephus*.

And

And it seems somewhat strange to many, that Christ should in St. *Luke* admonish his hearers to fly out of *Jerusalem* and *Judea*, and not resort thither from the neighbouring countries, when they should see *Jerusalem* encompassed with armies, since those armies would probably hinder the counselled retirement (at least as to the city). Whereas he that finds in the story, that the Roman forces under *Gratus* did on a sudden, and (as good authors tell us) without any manifest cause, withdraw from the siege of *Jerusalem*, and then return to it again, and (under *Titus*) carry the town by force; he that shall read also in *Euseb. lib. 3. cap. 5.* that the Christians of *Jerusalem* did (divinely admonished) make use of the opportunity presented them to quit all of them the city, and retire to *Pella* on the other side of *Jordan*; he, I say, that shall read and take notice of all this, will not only clearly understand the reasonableness of our Saviour's warning, but admire the prophetic spirit by which he could give it. And as it is difficult to collect out of the old testament alone the history of those times, wherein it was written; so it is not to be expected, that out of those books we should be able to collect and comprehend, either complete ideas of the Israelitish government, civil and ecclesiastical, or the true state of their several sects, opinions and affairs in matters of religion: and yet without the knowledge of those it cannot be, but that many texts will seem obscure to us, which were not at all so to them, that were coetaneous to the pen-men of those books. The labours of some modern criticks, that have put themselves to the trouble of making a thorough search into the writings of those Jewish Rabbies, that lived about our Saviour's and his Apostles times, have, by the help of the rabbinical learning, already cleared up divers texts, which before were dark, because they related to particular sects, customs, sayings, or opinions amongst the then Jews, whose knowledge, the writers of the new testament do not teach, but suppose. And I doubt not, but higher and valuable attainments in that kind of learning (how worthless soever I should think it, if it were not conducive to the illustration of the scripture) will, ere it be very long, disperse that obscurity, which yet dwells upon divers other texts, and will shew the groundlessness of all our cavils at them, as well as that of many of our too fierce contentions about them. I shall add, that I dare almost presume to question, whether even our famousst critics have not left divers Mosaic texts in the dark, if not clouded them by their comments, merely for want of knowing the religion of the antient Zabians, in opposition of whose magical worship and superstitions, I am apt to think divers ceremonies of the ritual law of the Jews to have been instituted. And yet of those Zabiists (or צב"ים and צבאים as the Hebrews and Arabians express the name) I find a deep and general silence in classic authors, except (the Rabbi's oracle) *Mainonides*, out of whom our great antiquary (Mr. *Selden*) both in familiar discourse, and in his excellent tract of the Syrian deities, gave me first a hint, which by lighting on another author of those parts, I have since had the luck to improve sufficiently, to make me fear, that they, who are strangers to the Zabians rites and creed, will scarce give us the clearest account the theme is capable of in divers passages of the Mosaic law. As I am apt to think, that our ignorance or want of taking notice of the persuasions and practices of the Gnosticks, Carpocratians, and the sects allied to theirs, if it do not make us mistake and misinterpret, doth at least keep us from giving the clearest interpretations, whereof they are capable, to many passages of the New Testament, wherein they are either clearly pointed at, or closely related to.

3. We may reasonably suppose, that of the texts, that are now difficult unto us, there are divers that are so, but because they were principally intended for the use of those that shall live in after-times, by whom they will questionless be better understood. To the Jews, that lived in and along after *Moses* his time, many of those predictions, both verbal and typical, of the *Messias*, seemed very dark, which to us

Luke xxi.
21, 22.

Christians are abundantly illustrated by the rising of that sun of righteousness, who was aimed at in them. And though the mysterious temple and city described in *Ezekiel*, as also much of the *Apocalypse*, and divers other prophetick passages of holy writ, do yet seem abstruse to us; yet they will not appear so to those, to whom their completion (the best expositor of dark prophecies) shall have unfolded them. For I observe, that as some divine predictions are clearly expressed, to the intent that those, that are made acquainted with them, may before-hand know what will happen, so others are proposed, not so much that those, to whom they are first addressed, should know the fore-told events, before they do come to pass, as that, when they do come to pass, the same accomplishment, that expounds them, may evince, that the foreteller of them was able to foresee them, according to that of our Saviour to his disciples, to whom he prophesied the sufferings they should undergo; *These things have I told you, that when the time shall come, ye may remember that I told you of them.*

John xxvi.
4.

4. It was fit, that there should be some obscure passages left in the inspired volume, to keep those from the knowledge of some of those divine mysteries, that are both delightful and useful, though not absolutely necessary, who do not think such knowledge worth studying for. As it was also fit (which I partly noted above) that there should be some clouded and mysterious texts, to excite and recompence the industry and speculation of elevated wits and religious inquirers.

Lastly, THERE are divers obscure passages in scripture, wherein the difficulty lies in the thing it self that is expressed, not in the scripture's manner of expressing it. For not to mention that obscureness, that is wont to attend prophetick raptures, (of which there are many mentioned in the scripture) there are divers things, that we agree to be knowable by the bare light of nature without revelation, which yet are so uneasy to be satisfactorily understood by our imperfect intellects, that let them be delivered in the clearest expressions men can devise, the notions themselves will yet appear obscure. Thus in natural philosophy it self, the nature of place and time, the origin of motion, and the manner whereby the human soul performs her functions, are things, which no writers delivered so clearly, as not to leave the things somewhat obscure to inquisitive and examining readers. And shall we then wonder, that those texts of scripture, that treat of the nature and decrees of God, and of such sublime mysteries as the trinity, the incarnation, the influence of the spirit upon the soul of man, and such other abstruse things, which it cannot be reasonably expected that human words should keep from being hard to be comprehended by human understanding, should be obscure to us; especially if we suffer our not understanding their full meaning at first to deter us from endeavouring to find it out by further study. I am sorry I can add on this occasion, that divers texts are made to appear more dark, than otherways they would, by the glosses and interpretations of some, that pretend to expound them. For there are divers subtle men, who being persuaded, upon certain metaphysical notions they are fond of, or by the authority of such either churches or persons as they highly reverence, that such or such niceties are either requisite to the explication of this, or that doctrine delivered in scripture, or, at least, deducible from it, will make bold so to interpret dark texts, (and sometimes even clear ones) that they shall seem to hold forth, not only their own sense, but the nice speculations, or deductions of him that quotes them: so that divers texts, which, to a rational and unprepossessed peruser, would appear plain enough, seem to contain inextricable difficulties to those unwary or prejudicate who are not careful to distinguish betwixt the plain sense of the text it self, and those metaphysical subtleties, which witty and interested persons would father upon it; though oftentimes those niceties are either so groundless, that though there needs much wit to devise them, there needs but a little reason to despise them;

or

or so unintelligible, as to tempt a considering man to suspect, that the proposers either mean not what they speak, or understand not what they say. And I could wish these metaphysical quirks, with which several, not only school-men, but other writers, have perplexed the doctrine of predestination, of the trinity, of the operation of the spirit of God upon the will of man, and some other mysteries of Christian religion, did not give advantages against those doctrines to the opposers of them, and perhaps make some men opposers, who otherwise would not have been so. And I fear, that too great an opportunity has been afforded to atheistical wits, by unintelligible fancies, which many have made bold to add to what the scripture has revealed, concerning the eternity and infiniteness of God. For whilst men indiscreetly and unskilfully twist together, as integral parts of the same doctrine, a revealed truth with their own metaphysical speculations about it, though these be too often such as cannot be proved, or perhaps so much as understood; they tempt such examining readers, as are rational enough to discern the groundlessness of one part of the doctrine, to reject the whole for its sake. But I fear I have digressed, for my intention was only to intimate, that it is not oftentimes so much what the scripture says, as what some men persuade others it says, that makes it seem obscure: and that as to some other passages, that are so indeed, since it is the abstruseness of what is taught in them that makes them almost inevitably so, it is little less faulty, upon such a score, to find fault with the style of the scripture, than to do so with the author for making us but men.

THUS much being said, by way of answer, to the first sort of objectors of darkness against the scripture, it is easy to foresee, that the second sort of them may endeavour to pervert what has been delivered to apologize for their neglect of the scripture, by alledging, that albeit what has been represented may serve to shew, that the obscurity of the scripture is justifiable; yet the very proving it needful or fit, that it should be obscure, is a plain confession that it is so. Wherefore it is requisite, that I now say something to this sort of objectors also, who are so unfavourable to the scripture and themselves, as that, because they cannot understand all of it, they will not endeavour to learn any thing from it. I have already acknowledged it, and shall not now deny, that (as heaven it self is not all stars) there may be parts of scripture, whose clear expositions shall ennoble and bless the remotest of succeeding ages, that perhaps some mysteries are so obscure, that they are reserved to the illumination and blazes of the last and universal fire.

BUT here it would be considered in the first place, that those texts, that are so difficult to be understood, are not necessary to be so. In points fundamental and indispensably necessary, the darkness of scripture is no less partial, than that of *Egypt*, which benighted only the enemies, but involved not the people of God: in such articles as these, *If the gospel be hid, it is hid to them that are lost, in whom the God of this world hath blinded the minds.* At least in relation to such truths as these, we may justly apply that of *Moses*, where he tells *Israel*, *This commandment, which I command thee this day, is not bidden from thee, neither is it far off. But the word is very near unto thee, in thy mouth, and in thy heart, that thou mayest do it.* And surely the Bible's being appropriate (as it self tells us) *to enlighten the eyes, and to make wise the simple*; and it being written for the use of the whole people of God, whereof the greater number are no clerks, things are there expressed with an evidence proportionable to the degree of assent that they exact, and are as far forth intelligible to pious and industrious readers, as they are necessary to be understood by them; and we may not unfitly say of the understanding of those cloudy passages of scripture, what I remember a father said of the sacrament, *That not the wanting of it, but the slighting it shall condemn men.* It is our duty to study them, but it is not (always) to understand them.

2 Cor. iii. 4.

Deut. xxx.
11, 12, 13,
14.

Psal. xix.
7, 8.

Non privatio, sed contemptus damnat.

AND as the knowledge of those texts that are obscure, is not necessary, so those others, whose sense is necessary to be understood, are easy enough to be so. And those are as much more numerous than the others, as more clear. Yes, there are shining passages enough in scripture, to light us the way to heaven, though some unobvious stars of that bright sphere cannot be discerned without the help of a telescope. Since God, then, has been pleased to provide sufficiently for our instruction, what reason have we to repine, if he have in a book, not designed for us alone, provided also for those, that are fitted for higher attainments? especially since, if we be not wanting to ourselves, those passages, that are so obscure as to teach us nothing else, may at least teach us humility.

NOR does it misbecome God's goodness, any more than his wisdom, to have so tempered the canonical books, as therein to leave all sorts of readers an exercise for their industry, and give even the greatest doctors continual inducements to implore his instructions, and depend on him for his irradiations, by leaving, amongst many passages, that stoop unto our weakness, some that may make us sensible of it. It should, methinks, be looked upon as the prerogative, not the disparagement, of the scriptures, that the revelation of his truth, vouchsafed us by God in them, is like a river, wherein a lamb may quench his thirst, and which an elephant cannot exhaust. I should think him but an ill-natured child, who should be angry to see strong meat provided for his elder brothers, because he himself can yet digest nothing but milk: and as the same child, being grown up to riper years, would be then troubled, that, according to his first envious wish, there were no stronger aliment provided in the family than milk; so when, by the attentive and repeated perusal of the scripture, a child in knowledge shall attain to some higher measure of skill in the scriptures, he will then be well pleased to have his understanding exercised by those most mysterious texts, of which he formerly complained that they surpassed it. However, since there are so many plain passages of scripture, that clearly hold forth, not only all that is necessary for us to know, but, I fear, much more than we are careful to learn and practise, the zealous Christian would no more decline feeding on this heavenly food, though all the hard places should still remain such to him, than the Jews would forbear to eat the paschal lamb, *though not a bone of it were broken*. And, in earnest, would not he merit unrelieved beggary, that should refuse the profit of a rich mine, because all those of the world are not yet discovered, nor those of the *Indies* exhausted?

Exod. xiii.
46.

MOREOVER, the pretended obscureness of the Bible is a mistaken discouragement from reading it: for the frequency of reading it still lessens that obscurity; which, like a mist, seems thicker at a distance, than when one enters it, and attempts a passage through it; which, in our case, many pious students have done so prosperously, as to find, by welcome experience, that what, at a distance, deterred them, was not intended to frustrate industry, but punish laziness.

BESIDES that, the scripture being avowedly the best expositor of itself, our ignorance of those places, whose sense we seek for, makes us often occasionally much knowinger, and more perfect in the meaning of all the rest; and makes us too so much more ready in the uses of them, that I cannot but apply to this subject the fable of that dying husbandman, who, by telling his sons of a hidden mass of wealth he had buried in a nameless place of his vineyard, occasioned their so sedulous delving all the ground, and turning up the earth about the roots of the vines, that they found indeed a treasure, though not in gold, in wine: for thus out of hope, by the light of understood scriptures, to penetrate the sense of the obscurer ones, we occasionally so improve our knowledge and readiness in the clearer passages, that our by-acquists do richly recompence our frustrated (or rather unsuccessing) pains; since our particular
disappointments

disappointments hinder not the promotion of our general design, which is a greater proficiency in spiritual knowledge, and therefore ought not to deter us from the duty of those searches, in which not only to discover is happy, but even the unsuccessful attempts are gainful, whatever the event be; the pains being seldom fruitless, but reaching either their end or recompence. And this prompts me to represent to you further, that not only the scripture is instructive upon the same account with other theological writings, but that we may hope to improve our understandings by it upon this score, that it is also the instituted means, as well of knowledge, as of grace, and appointed for our instruction by him, who, as sin came into the world by man's listening to the words of the devil, is pleased to make restoring-grace operate chiefly by our listening to the word of God, whether heard or read. Wherefore those, whom the intuition of this encouragement invites to be diligent perusers of the scripture, do to their unfirm understandings, as the inhabitants of *Genazareth* did to their sick and weak countrymen, lay them in *Jesus* his way, and consequently in that of recovery. It is of (at least one of) the darkest books of the scripture, that it is said, *Blessed is he that readeth, and they that hear the words of this prophecy*. The eunuch in the *Acts* would (though upon the highway) needs read the Prophet *Isaiah*, and though (as appears by his question to *Philip*) as then he understood not what he read, yet did the Spirit take thence (perhaps a rise, as well as) opportunity to reveal Christ unto him, and both satisfy him of the meaning of that prediction, and acquaint him with the fresh and happy accomplishment of it. And surely this consideration of the Bible being one of the conduit-pipes, through which God hath appointed to convey his truths, as well as graces, to his children, should, methinks, both hugely animate to the searching of the scriptures, and equally refresh us in it. For as no instrument is weak in an omnipotent hand, so ought no means to be looked upon as more promising, than that which is like to be prospered by grace, as it is devised by omniscience. We may confidently expect God's blessing upon his own institutions, since we know, *that whatsoever we ask according to the will of God, he will give it us*; and we can scarce ask any thing more agreeable to the will of God, than the competent understanding of that book, wherein his will is contained.

Mark vii.
56.

Rev. i. 3.

1 John vi.
14.

THE difficulty ought not to deter us from the duty of searching the scriptures, the difficultest commands of God being a warrant to a believer's confidence of being enabled acceptably (though not exactly) to obey them; which St. *Peter* seems to have known well in the theory, though he failed in the practice, when to be enabled to walk upon the sea, he desires only, that our Saviour would please to command him to come to him upon the water. The Bible is indeed, amongst books, what the diamond is amongst stones, the preciousst, and the sparklingst, the most apt to scatter light, and yet the solidest, and the most proper to make impressions. But were it as unsuitable to its end, as it is the contrary, I should remember, that our Saviour could successively employ even clay and spittle to illuminate blind eyes: and though I thought the Bible to be, on other accounts, no more than equal to other books of morality and devotion, God's designation would make me study it more hopefully, by minding me of that of the Syrian leper, when he would needs have *Albana* and *Parphar*, rivers of *Damascus*, likely to be as medicinal for his disease as *Jordan*; and vainly fancied, that God's appointment could not put a difference betwixt things that knew no other.

Matth. xi.
28.

John ix: 6.

2 Kings v.
12.

I KNOW, that because of the intermixture of some obscurer texts of scripture with the clear ones, there are divers well-meaning, and even devout persons, that leave the study of it for that of other books of religion, which, by leaving out all such difficult matters, seem to promise more of instruction. But, notwithstanding this, I shall

shall not much scruple to affirm, that as the moon, for all those darker parts we call her spots, gives us a much greater light than the stars, that seem all luminous; so will the scripture, for all its obscurer passages, afford the Christian and Divine more light than the brightest human authors.

To dispatch, since the scripture is both a naturally proper, and an instituted instrument, to convey revealed knowledge to the studiers of it; and, in it, many clear passages may instruct ordinary capacities; and its darker ones may either recompense more inquisitive wits, or humble them: I see not, why the obscurity of a small part of it should deter any sort of pious persons from the perusal of the whole. And, as the word of God is termed a *light*, so hath it this property of what it is called, that both the plainest rusticks may, if they will not wilfully shut their eyes, by the benefit of its light, direct their steps, and the deepest philosophers may be exercised, if not posed and dazzled, with its abstruser mysteries. For, thus, in the scripture, the ignorant may learn all requisite knowledge, and the most knowing may learn to discern their ignorance.

Psalm. cix.
205.
Prov. vi.
23.

The second OBJECTION.

To proceed now to the second objection against the style of scripture: the seemingly disjointed method of that book is by many much cavilled at; to which, were the supposal a truth, I might reply, that the book of grace doth but therein resemble the book of nature; wherein the stars (however astronomers have been pleased to form their constellations) are not more nicely or methodically placed, than the passages of scripture, that where there's nothing but choice flowers, in what order soever you find them, they will make a good posy: that it became not the majesty of God to suffer himself to be fettered to human laws of method, which, devised only for your own narrow and low conceptions, would sometimes be improper for, and injurious to his, who may well say (as he doth in the Prophet) that his thoughts are so far from being ours, that, *As the heavens are higher than the earth, so are his thoughts higher than our thoughts*; that, as a mixture of amber-grease and musk is more redolent than the single ingredients; and as, in compound medicines, (as mithridate and treacle) the mixture gives the electuary a higher virtue than the severer drugs possessed; so, oftentimes in morality and divinity, a complication of precept and example, of rhetorick and mystery, may operate better than their distinction would. And sure we should judge that man a very captious creature, that should take exception at a proffered sum, only because the half-crowns, shillings, and sixpences, were not sorted in distinct heaps, but huddled into one. This, I say, with much more, might be represented, were the scripture-series as destitute of method, as pretended. But the truth is, that the method, though it be not pedantically nice, is proper and excellent: (if the goodness of a method be to be judged less by the order of the sections, than its being in order to the author's end) and never swerved from, but upon sufficient ground, or for some mysterious purpose; the laws of order in the scripture being rarely declined, but, as the laws of nature are in the world, for man's instruction. The historical dislocations have their particular reasons, and, for the most part, are accounted for by judicious expositors: and as for the frequent (and sometimes long) digressions, excepted against in the epistles of St. Paul, were he a bare human writer, I should possibly attribute his frequent excursions to his fulness upon all subjects, not his want of skill to prosecute any one; and compare his pen to those generous horses, who, though never so well managed, will ever be jetting out on this or that side of the path, not out of undisciplinements, but purely out of mettle. But, looking upon St. Paul under another notion, I shall rather choose to tell you, that

Isa. lv. 8, 9.

that as rivers are said to run to the sea, though often-times the interposition of hard, or rising grounds, or other obstacles, force them to such winding meanders, that they seem to retreat from the ocean they tend to; which nevertheless, with increased streams, they afterwards bend again their intermitted course to, having watered and fertilized, by their passage, the grounds, through which they seemed to wander; so our Apostle, though he direct his course to his main scope, may not only without declining it, but in order to it, (for in some cases the wisdom of the proverb will inform us, that the longest way about, is the nearest way home) seem for a while to abandon it, by fetching a compass to answer some obvious, or anticipate some tacit objection; and afterwards more prosperously resume his former considerations, now strengthened by the defeat of the interposing scruples, having by the by happily illustrated and enriched those subjects, which his incidental excursions led him occasionally to handle. I must add, that in St. Paul's, as in the rest of the inspired writings, the meer want of heeding the Holy Ghost's way of writing makes the method appear to us at a very great disadvantage. For in the historical parts of scripture, when the order of time is interrupted, those προύζερα προλήψεις and επάνοδοι, and such dislocations, are used oftentimes only to comply with the connexion of the matter; and either dispatch all that belongs to the same long narrative at once, or else to join passages allied in some other circumstance, though severed in that of time; and sometimes too things are inserted, which do not readily seem pertinent to the series of the discourse, but are extremely so to some scope of the author, and afford much light and excellent hints to the reader. Sometimes the coherence, where it appears defective, may be very well made out, by rendering Hebrew verbs (and some Greek aorists) in a preterpluperfect sense instead of a perfect; or by some such other grammatical variation of the words, as all, that understand Hebrew well, know to be allowed by the propriety of that tongue, which ignores divers moods and tenses, &c. of our western languages. Sometimes that, which seems incoherent to a discourse, serves really to prevent a foreseen (though perhaps not always obvious) probability of the misapplication of it; and so must not be judged impertinent to a doctrine, which it hinders from being either scrupled at, or abused. Sometimes the prophets in the midst of the mention of particular mercies promised to, or judgments denounced against the people of God, fall out into pathetical excursions relating to the Messiah, which seem extremely abrupt and incoherent with the rest to them, that consider not how seasonable the mention of Christ may be, both in that of the mercies of God, of which he is the foundation and pinnacle, the ground and consummation, (and the promise made of him, taught the faithful to reason thus with his Apostle, *He that spared not his own Son, but delivered him up for us all, how shall he not, with him, also freely give us all things?*) and with the threats of the judgments of God, in which he was his people's grand consolation. Sometimes ο διδάσκαλος, the teacher, that bishop of our souls, who was in the supreme degree of perfection, which St. Paul required of a bishop, διδαντικός, both fit and forward to teach, takes a rise from any invitation, either of a word, expression, or theme, though belonging to his own first subject, to give further instructions, by digressing a little to that occasional and intervening theme; which, however it related to his matter, suited very well with his merciful inclinations to instruct dim mortals. Sometimes, nay oftentimes, the inspired discourses seem to say things, not only incoherent, but contradictory; (as is very remarkable in divers of St. Paul's epistles, where he seems to praise and dispraise the same persons) whereas addressing themselves to mixt assemblies, wherein (as Noah and Ham in the ark, and the tares and the wheat in agro Dominico) they were both good and bad men, hereticks, especially Gnosticks, and orthodox Christians; they

Rom. viii.
32.

John xiii.
13.
2 Pet. xi.
25.
1 Tim. iii.
2.

only

only so wisely dispensed and tempered their discourse, that both these sorts of persons might find something, in what was in general terms delivered, to appropriate to themselves in particular; which application was necessarily left to their own consciences to make. Sometimes the order is in scripture much disturbed, or injured, by the omission or misplacing of a parenthesis. For there not being any in the Hebrew copies, nor (as it is thought) in the original Greek ones, the publishers of the several editions of the Bible have placed parentheses as they have judged most convenient; some including in them what others leave out of them; and some making long ones, where others make none at all; and perhaps none of them having been so happy, as to leave no room for alterations, that may deserve the title of corrections and amendments. And sometimes too, the seeming immethodicalness of the new testament (not to determine any thing of the antiquity, which is certainly great, and the authority of the accents, and partition of the old testament, because amongst very able criticks *adhuc sub judice lis est*) is due to the inconvenient distinction of chapters and verses now in use: which though it be a very great help to the memory, and be some other ways serviceable; yet being of no greater antiquity than its contriver *Stephanus*, and being (though now of general use) but of private authority, and by him drawn up in haste; it will be perhaps no slander to that industrious promoter of heavenly learning, to say, he hath sometimes severed matters, that should have been left united, and united others, which more conveniently he might have severed; and that his lucky attempt ought not to lay any restraint upon the other learned men, from making use of the same liberty he took in altering the former partitions, (for of them I speak, not of the punctuation) of the new testament, in altering his alterations, to the best advantage of the sense or method. The analytical works of some (I wish I could say many) judicious expositors and divines upon the scripture may sufficiently manifest its being generally reducible enough to a perspicuous order; and that it conforms to the known laws of method, where its diviner one doth not transcend them. And it were not impossible for me to give divers instances to manifest, that as the north-star, though it be less luminous than many others, yet, by reason of its position, doth better guide the pilot, than even the moon herself: so there are some texts in scripture, which, though less conspicuous in themselves, are, by reason of their relation to a context, more instructive than other more radiant passages; to which these would be much inferior, if they were not as well considerable for their being there, as such.

The third OBJECTION.

ALLIED to their objection, who find fault with the scripture for being immethodical, is theirs, who would fain persuade us, that it is seldom coherent, and scarce any where discursive. And I have observed, with trouble, that even some pious readers are easily tempted to look upon the Bible as barely a repository of sentences and clauses, where divine truths lie huddled, and not ranged, and are too ready to apply to its texts the title *Nero* gave *Seneca's* style, of *arena sine calce*. Whereas an intelligent and attentive peruser may clearly enough discern, both that the prophets and apostles do make frequent deductions and inferences, and that their arguments, though not cast into mood and figure, are oftentimes as cogent as theirs, that use to make syllogisms in *Barbara*. I frequently entertain my self with both those authors, and yet methinks, *St. Paul* reasons as solidly, and as acutely, as *Aristotle*: and certainly according to *David's* logick, (*He that planted the ear, shall he not hear? He that framed the eye, shall he not see? He that teacheth man knowledge, shall not he know?*) the first and grand author of reason should as well know how to manage and disclose

disclose that faculty, as they that possess it but by participation, and glister so but with some few condescending beams, vouchsafed by that bright sun, who is indeed the *father of lights*, from which each good and perfect gift descends. But on this occasion, to point at a few particulars, I consider,

Jam. i. 17.

1. THAT some ratiocinations of scriptures remain undiscerned or misunderstood, because of our unacquaintedness with the figurative, and (oftentimes) abrupt way of arguing, usual among the Eastern people, who in their arguments used to leave much to the discretion and collection of those they dealt with; and discoursed at a wide distance from the logical forms of our European schools, as to persons versed in their writings cannot but be notorious.

2. THAT the seeming incoherency of many ratiocinations proceeds purely from the misrendering of the original particles, especially of the Hebrew conjunction copulative *Vau*, or *Vaf*, (as it is diversly pronounced by the Jews, of whom I shall here advertise you once for all, that they have confessed to me, they differ in pronouncing Hebrew, not only from the Christians, but exceedingly from one another) for there is hardly any of those particles, that hath not, besides the obvious various significations, of which, if that were skilfully and freely in every text taken up, that would there afford the best sense, the scripture would, I am confident, appear much more coherent and argumentative than translations or expositors are wont to make it: and though I did but consider, how many thousand times the particle *Vaf*, is used in the scripture, and that it doth not only (though it do primarily) signify AND, but hath also (I speak within compass) four or five and twenty other significations (as *that, but, or, so, when, therefore, yet, then, because, now, as, though, &c.*) and that the sense only gives it this great diversity of acceptations; I cannot but think, that if we always allowed our selves an equal freedom in rendering it, where the motive (which is the exigency or conveniency of the sense) is the same; the dextrous use and rendering of that one particle would make no small number of texts both better understood, and more esteemed.

3. THAT sometimes (especially in *Solomon's* and *St. Paul's* writings) in many passages so penned as to contain (like *Seneca's*) a tacit kind of dialogue, that is unskilfully by readers, and even interpreters, taken for an argument or an assertion, which is indeed an objection: and that such a mistake must mightily discompose the contexture of a discourse, even a raw logician need not to be told.

4. THAT the omission or misplacing of parentheses (which the Hebrew text altogether wanting, interpreters have supplied and used at their own discretion) makes the scripture oftentimes appear less discursive, as well as (what we elsewhere complain of) less methodical. And the like may be said of the points of interrogation. For whether it be true or no what the critics esteem, that in the original Greek copies of the new testament there were no such points, (as indeed I have found them wanting in the ancientest manuscripts I have seen) it is certain, that in our modern copies, both Greek and translated, the authors of several editions have variously placed them, as themselves thought fit: and though, instead of the interrogative point, the Hebrews make use of their interrogative *He*; yet that the sense of the words, and a certain supposed modulation, do oftentimes make an interrogation, where that *He* is wanting, an Hebrician can scarcely ignore, no more than a logician, that the interrogation is not always supplied to the best advantage of the scripture's logick.

5. THAT the apostles and other inspired discoursers in the Bible divers times use arguments, not to convince opposers, but to confirm believers. For the persons they reason with, being such, oftentimes, as esteem them teachers sent from God, upon

whose score all they teach exacts belief, they may without irrationality use arguments to confirm in their doctrine men already acquiescing in the principles of it, and persuaded of their integrity, sufficiency, and authority, that it would be improper to urge against a refractory disbeliever, that is convinced of none of these. And as masters often use, in instructing their scholars, arguments, they would forbear to insist on against a professed antagonist; so the apostles dealing with those, that thought them inspired teachers, and fully instructed in the mysteries of scripture, and the designed dispensations of God, might justly draw inferences, not to be urged against an infidel, from a doctrine first delivered by themselves, or from a text or passage, wherein those, they reasoned with, justly supposed they might know more of the mind and counsel of God than other men; and would teach nothing as such, that was not so.

6. THAT arguments exquisite, and (as artists term them) apodictical, had been oftentimes less proper in discourses, which being address'd to popular auditories, required rather popular arguments; which the inspired discourses employ, but as likely to be better understood, and more prevalent than those, which are so logical, that they require logicians to relish them. Where teaching and persuading is the design, not only the native cogency of a ratiocination is to be considered, but its proportion to their spirits it is address'd to, and its aptitude to work upon them. For as a spider will catch flies better than a hawk can; as a cat is more fit to destroy mice than a grey-hound, though this be stronger and swifter; and as the crowing of a cock will (according to famous naturalists) sooner fright a lion than the bellowing of a bull, though the latter be much the more terrifying noise, and proceed from the more formidable animal: so oftentimes weaker and popular arguments succeed better with a resembling auditory, than the irrefragable syllogisms.

7. THAT divers scripture-arguments do not logically and cogently prove the thing they would persuade, merely because they were meant only for what logicians call *argumenta ad hominem*; (reasonings designed not so properly to demonstrate the opinion they contend for, irrelatively and abstractedly considered, as to convince, of the truth of that opinion, the persons they are address'd to) and consequently the inspired discourses arguing *è concessis*, from principles conceded and confessed by those they reason with, though the principles should be unsolid, the ratiocination is not. Thus there are divers texts of the old testament applied to Christ in the new, which though they did not now inevitably conclude against the present Jews, were without any illogicalness employed against their ancestors; because then the relation of those passages to the Messiah was so acknowledged, that there needed but the pertinent applications made of them in the new testament; whereas the refractoriness of the succeeding Jews hath taught them to devise so many sophistical evasions to elude the texts we speak of, that they now dispute, not only the application of them, but the explication too. St. Jude argues with the rodomonts of his time, out of the story of the arch-angels and the devil's contest about the body of *Moses*: and though perhaps that story be (like the Jewish book, whence it seems not improbable it was taken) somewhat apocryphal; yet as long as they revered it, it was not irrational in him to urge them with it, and employ it to the redargution of their insolence. And, although as there be nothing less solid and more fickle than the wind, yet the skilful pilot diligently observes it, and makes it drive on his ship more forcibly, than the powerfullest and best contrived engines in the world could; so though there be scarce any thing more groundless and unstable than popular opinions and persuasions, yet a wise teacher neglects them not, and may sometimes make such use of them, as to draw thence arguments more operative than the accuratest syllogisms logick could

could devise. And indeed the most convincing proofs of assertions being ever afforded by the mediums, wherein both parties agree, not only *Socrates* in *Plato's* dialogues, but dextrous discourses generally, have often elected the drawing of inferences from the opinions and concessions of those they dealt with, as the most persuasive and successful way of arguing; to all which I shall add,

8. THAT another thing, which very generally keeps men from discerning the reasonings (and consequently oftentimes the reasonableness and true sense) of scripture texts, is, the shiness of divines to let the context and the speaker's scope regulate their choice, amongst all the various, though not equally obvious, significations of ambiguous words and phrases. It is not, that (as far as I have observed) men almost of all religions are not wont to make bold with (and perhaps for a need to strain or wrest) phrases and words of scripture, when the giving them less usual notions may fit them to serve their turns; but the mischief is, that they decline the commonest acceptations, but to make the texts they quit them in, symphonize with their tenents, not with their neighbouring texts. It were methinks impartialler, if the frequenter sense of an expression were to be waved (as oftentimes it must) for one less current, to do this to make the scripture coherent, or discursive: and then, for our opinions, rather to conform them to the sense of the scripture, than wrest the words of scripture to them. But perhaps this impartiality would silence too many of our clamorous controversies (by shewing some to be groundless, and others undeterminable) to be likely to take place in the heated spirits of men; some of whom, I fear, whilst their feuds and fierceness last, would be willing to have the texts of scripture loose stones, which they may more easily throw at their adversaries, than built up into a structure, wherein they must lose that convenience, (it being difficult to pluck stones out of a building) though reason herself were the architect.

BUT to leave these eager disputants to their animosities, we shall again repeat, that the Bible loses much by not being considered as a system. For though many other books are comparable to cloth, in which by a small pattern we may safely judge of the whole piece; yet the Bible is like a fair suit of arras, of which, though a thread may assure you of the fineness of the colours, and richness of the stuff, yet the hangings never appear to their true advantage, but when they are displayed to their full dimensions, and seen together.

THESE things, *Theophilus*, among many others, may be represented on the behalf of the scripture, against those, who will needs censure it as a collection, not to say a heap of immethodical and incoherent passages. But lest you should suspect me of partiality, I should ingenuously confess to you, that there are some things in the oeconomy of scripture, that do somewhat distress my reason to find a satisfactory account of; and that there are very few things, wherein my curiosity is more concerned, and would more welcome a resolution in. But when I remember, how many things I once thought incoherent, in which I now think I discern a close (though mystick) connection; when I reflect on the author and the ends of the scripture; and when I allow myself to imagine how exquisite a symmetry (though as yet undiscerned by me) omniscience doth, and after-ages (probably) will discover in the scripture's method, in spite of those seeming discomposures that now puzzle me: when I think upon all this, I say, I think it just to check my forward thoughts, that would either presume to know all the reclusive ends of omniscience, or peremptorily judge of the fitness of means to ends unknown; and am reduced to think that oeconomy the wisest, that is chosen by a wisdom so boundless, that it can at once survey all expedients, and so unbiassed, that it hath no interest to chuse any, but for

its being fittest. I shall annex, that I think those must derogate hugely from the scripture, who only consider the sense of the particular sections, or even books of it: for I conceive, that (as in a lovely face, though the eye, the nose, the lips, and the other parts singly looked on may beget delight and deserve praise, yet the whole face must necessarily lose much by not being seen all together; so) though the severed leaves and portions of scripture do irrelatively, and in themselves, sufficiently betray and evidence their own heavenly extraction; yet he, that shall attentively survey that whole body of canonical writings we now call the Bible, and shall judiciously in their system compare and confer them to each other, may discern, upon the whole matter, so admirable a contexture and disposition, as may manifest that book to be the work of the same wisdom, that so accurately composed the book of nature, and so divinely contrived this vast fabrick of the world. The books of scripture illustrate and expound each other; *Genesis* and the *Apocalypse* are in some things reciprocal commentaries; (as in trigonometry the distantest side and angle use best to help us to the knowledge one of the other:) and as in the mariners compass, the needle's extremity, though it seem to point purposely but at the north, doth yet at the same time discover both east and west, as distant as they are from it, and from each other; so do some texts of scripture guide us to the intelligence of others, from which they are widely distant in the Bible, and seem so in the sense. It is as high as pious a satisfaction to observe, how the sacred pen-men supply each other's omissions, (as is very observable in the four Evangelists mention of the genealogy of Christ) according to God's degrees and seasons in dispensing the knowledge of his truths and mysteries in the several ages of the church; (to which he at first vouchsafed *but a light shining in a dark place until the day dawn*, and to which these mutual irradiations and secret references persuade, that all these reputed authors had their pens guided by an omniscient hand, and were but the several secretaries of the same enditer) and to find in writers severed by so many ages, and regions, a harmony, whose dissonances serve but to manifest the sincerity and unspiringness of the writers. And truly for my part, I am professedly enough an impartialist, not to stick to confess to you, *Theophilus*, that I read the Bible and the learnedest expositors on it, with somewhat particular aims and dispositions. For besides, that I come not to them with a croud of articles, which I am there resolved to find or make arguments to defend, with the overthrow of all antagonists, esteeming it less safe to carry my opinions to the scriptures than to take them up there: besides this, I say, though I neglect not those clear passages or arguments, that may establish the doctrine of that church I most adhere to; yet I am much less busied, and concerned to collect those subtle glosses or inferences, that can but enable me to serve one subdivision of Christians against another, than heedfully to make such observations, as may solidly justify to my own thoughts, and improve in them, a reverence for the scripture it self, and Christianity in general; such observations as may disclose to me in the Bible, and the grand articles clearly delivered in it, a majesty and an excellency becoming God himself, and transcending any other author; and such observations (to dispatch) as may unveil to me in the scripture, and what it treats of, that πολυκόινος σοφία τῆ Θεῆ, manifold wisdom of God, which even the angels learn by the church. These are, I confess, the things (as to speculative divinity) that I gladliest meet with, and take the heedfullest notice of, in the writings of divines, of whatsoever religion, that owns the scripture; (for in this I am almost equally gratified by the abler expositors of all dissenting sects:) for I can scarce think any pains mispent, that brings me in solid evidences of that great truth, that the scripture is the word of God, which is indeed the grand fundamental; all other articles generally thought so being, if truths, better deducible

2 Pet. l.
19.

Ep. iii. 10.

deducible from this one, than this from any of them. And I use the scripture, not as an arsenal, to be resorted to only for arms and weapons to defend this party, or defeat its enemies, but as a matchless temple, where I delight to be, to contemplate the beauty, the symmetry, and the magnificence of the structure, and to increase my awe, and excite my devotion to the Deity there preached and adored.

The fourth OBJECTION.

THE apostle of the Gentiles teaching us, that the whole scripture (for so I should rather english the *Πᾶσα γραφή*, because there follows) is *θεόπνευστος* divinely inspired, and is profitable for doctrine, for conviction, for correction, for instruction in righteousness; that the man of God may be perfect, thoroughly furnished unto all good works: and the Apostle of the circumcision assuring us, that, *Prophecy came not in old time, by the will of man, but holy men of God spake as they were moved by the Holy Ghost*; we are not to believe, that so divine an inditer, by secretaries, most of them conspicuous by the gifts of prophecy or miracles, would solemnly publish to the world, and for his church, any thing, that ought indeed to be accounted impertinent or useless. And yet of these qualities, some persons, more bold than learned and considerate, are pleased to impeach many passages of scripture. But truly that God, who was so precisely exact, in the dimensions, proportions, and all other circumstances of the ancient tabernacle, though it were but a typical and temporary structure, ought to be supposed at least as careful to let nothing superfluous intrude into those volumes: which being consigned to the church, for the perpetual use and instruction of it, must contain nothing uncondusive to those designs; the least text in it being as contributory to the completing of the Bible, as every loop or pin was to the perfection of the tabernacle. God, by so great a condescension to the weakness of our capacities and memories, as the with-holding from the canon so many writings of *Solomon*, and so many of the oracles and miracles of our Saviour; and by so strangely preserving the whole scripture, (for the books pretended to be lost, though written by never so holy men, are either in our Bibles extant under other names, or cannot be demonstrated to have ever been canonical, that is, entrusted with the church as the infallible rule of faith and life) does, methinks, abundantly evince his design of in-chasing nothing there, that hath no tendency to his people's instruction. Were not my discourse confined by my occasions, and the fear of distressing your patience to somewhat narrow limits, I could easily by several instances of texts, seemingly useless, shew, how much men have been mistaken in imagining them such. Many passages, that at the first or second reading I could find nor guess no uses of, at the third or fourth I have discovered so pregnant in them, that I almost equally admired the richness of those texts, and my not discerning it sooner. A superficial and cursory perusal presents us many things as trivial or superfluous, which a perspicacious reflection discloses to be mysterious. And of so precious a quality is the knowledge of scripture, that no one part of it ought to be esteemed useless, if it may but felicitate or improve the understanding of any other; divine truths being of that worth, that the knowledge and acquit of a few of them as much out-values a greater knowledge of other things, as a jeweller's skill and stock is preferred before a mason's. And I consider here, that as the Bible was not written for any other particular time or people, but for the whole church militant diffused through all nations and ages; as many passages (as those opposed to the *Zabians* magical rites) have at first been necessary for the Jews, which lose the degree (at least) of that quality for us. For there are many others very useful, which will not perhaps be found so these many

Of texts
seemingly
impertinent
or useless.

2 Tim. iii.

15, 16.

1 Pet. xxii.

21.

ages;

Mat. xxvi.
27.
Mark xiv.
23.

Luke ii.

Mat. i.

John i. 22.

Mat. xxvi.
56.

Mat. xvii.
3, 8.

Joh. i. 55:

ages; being possibly reserved, by the prophetick spirit that indited them, (and whose omniscience comprizes and unites in one prospect all times, and all events) to quell some future foreseen heresy, which will not perhaps be born till we be dead; or resolve some yet unformed doubt, or confound some error, that hath not yet a name: so that all the parts of the scripture are useful in some ages, and some in all. We read in the gospel, that at the first institution of the eucharist, it was expressly said to the disciples concerning the sacramental wine, *Drink ye all of it*, whereas upon the exhibition of the bread the particle *all* is omitted. This difference, it is like, the primitive Christians marvelled at, and discerning no reason for it, might be tempted to think the passage useless or superfluous: but we that live in an age, wherein the cup is denied to much the greater part of the communicants, are invited not only to absolve the recording of this particularity, but to admire it. The ceremonial law, with all its mystick rites (which, like the manger of the shepherds, holds forth wrapped in his swathing-cloaths the infant Jesus) to many, that bestow the reading on it, seems scarce worth it: yet what use the Apostles made of it with the Jews; and how necessary the knowledge of it is yet to us, in our controversies with them, he, that is any thing versed in them, cannot ignore. And let me tell you, *Theophilus*, that those fundamental controversies are both more necessary and more worthy a wise man's study, than most of those comparatively trifling ones, that at present so miserably (not to say so causelessly) distract Christendom. How many passages of the prophets by lazy readers are thought to have no use, which, as the star did the wise men, lead the attentive considerers to Christ; and so loudly and harmoniously, together with *Moses's* typick shades, utter those words of the Baptist's, *Behold the Lamb of God that taketh away the sins of the world!* that I meet with numerous passages in the new testament, to which I cannot but apply what St. *Matthew* notes upon his narrative of our Saviour's apprehension: *All this was done, that the scriptures of the prophets might be fulfilled*; or rather now all this was so done, that they were fulfilled; for so oftentimes the context commands us to render the *we* in these citations, and which recall to my mind the history of the transfiguration; for as there the Apostles at first *saw Moses and Elias talking with Jesus*, but at the second view (when the cloud was with-drawn, and he had spoken to them) *saw none but Jesus only*; so such passages, as I am speaking of, in the law, the prophets, and the gospel, at first survey appear very distinct things, but upon a second inspection, and the access of more light from an attentive collation of things, they do all, as it were, vanish into Christ; of whom (to use an Apostle's terms) *Moses in the law and the prophets did write*: and at whom those types, and those predictions pointed. Those instances of the old testament, of the confused or dislocated mention of known pedigrees and stories, were possibly useless, and even troublesome to the ancient Jews; but serve us extremely to silence the cavils of the modern ones, when they would invalidate the new testament's authority; because in St. *Stephen's* narrative, and some of the Evangelist's genealogies, the Holy Ghost is pleased to employ, in the new testament, that obscure strain he had oftner used in the old: (and sure as insultingly as the Jews use to urge against us objections of that nature, I could readily retaliate, and repay them in the same coin, were there no common enemy, that might be advantaged by our quarrel, and employ either's arguments against both.) And as there are divers prophetic passages in the *Revelation*, which we know as little the use, as meaning of, which yet doubtlessly our posterity will not find barren, when once the accomplishment shall have proved the expositor of those predictions, whose event will (if it do nothing else) attest the omniscience of their inspirer: so possibly, of many Mosaick constitutions, whereof we Christians find excellent uses, most of the old Jews scarce knew

knew any; at least my conversation with our modern Rabbies shows me, that they, whilst they obstinately decline referring them to the Messias, can scarce make any more of the inspired and mysterious laws of *Moses*, (except those that relate to the Zabian superstition, with which too most of their doctors are as unacquainted as ours) than the Egyptians, or Gymnosophists, could of their sacrifices and other ritual devotions.

It is not, that I think all the books, that constitute the Bible, of equal necessity or equal usefulness, because they are of equal extraction; or that I esteem the church would lose as much in the prophecy of *Nabum*, as that of *Isaiab*; or in the book of *Ruth*, as in the epistle to the *Romans*, or the gospel of *John*, (as the fixed stars themselves, though of the same heaven, are not all of the same magnitude and lustre). But I esteem all the constituent books of scripture necessary to the canon of it; as two eyes, two ears, and the rest of the members are all necessary to the body; without divers of which it may be, but not be so perfect; and which are all of great, though not of equal usefulness. And perhaps it might too without hyperbole be said further, that as amongst the stars, that shine in the firmament, though there be a disparity of greatness compared one to another, yet they are all of them lucid and celestial bodies, and the least of them far vaster than any thing on earth; so of the two testaments, that compose the Bible, though there may be some disparity in relation to themselves, yet are they both heavenly and instructive volumes, and inestimably out-valuing any the earth affords, or human pens ever traced. And I must add, that as mineralists observe, that rich mines are wont to lie hid in those grounds, whose surface bears no fruit-trees, (too much maligned by the arsenical and resembling fumes) nor is well stored with useful plants or verdure; (as if God would endear those ill-favoured lands by giving them great portions) so divers passages of holy writ, which appear barren and unpromising to our first survey, and hold not obviously forth instructions or promises, being by a sedulous artist searched into, (and the original word ἐρυνῶν used in that text of *Search the Scriptures* does properly enough signify the searching for hid treasure) afford, out of their penetrated bowels, rich and precious mysteries of divinity.

John v. 39.

The fifth OBJECTION.

THE next thing imputed to the scripture is, that it contains many things trivial or impertinent; and it is not impossible, but that some things may seem so, though they are not: of this sort are disjointed speeches, and abrupt transitions observed in many of our Saviour's discourses; in which also we sometimes read him to have answered, without being asked the question, (though that be otherwise salvable by a critick) and sometimes to have answered to a quite other question than that he was asked. But this is not to be thought an absurdity, but an excellency in the replies of Christ; who possessing the prerogative of discerning hearts, did preach after that rate; his oratory took a shorter way than ours can follow it in: he prosecuted his design by altering his discourses; and wisely measured the fitness of his heavenly sermons, by their relation to his end, not his theme. For as he knew his hearers thoughts, he address'd himself to them; and reaching them in their earliest formation, and, as it were, their first cradles before they had leisure to pass into the tongue, he not more convinced his auditory by answering their thoughts, than by thus manifesting that he knew them. Of his so much undervalued parables, some, if not most, do (like those oysters that besides the meat they afford us, contain pearls) not only include excellent moralities, but comprise important prophecies. The parable of the pregnant grain of mustard-seed, that so suddenly grew to so large a plant, was a (now fulfilled) prediction of the admirably

Mat. xiii.
31, 32.

Mat. xxi.
33.

Ec. xii. 1.

Gen. xli.
25. 31.

mirably swift progress of the gospel; which from despicable beginnings, soon prospered to a height, that rendered it almost as fit an object for wonder as for faith. That other parable of the treacherous husband-men clearly foretold Christ's death by the Jews malice, and their destruction for it. And I despair not to see unheeded prophecies disclosed in others of them, especially being informed that there is a critick, (Monsieur A. B.) now at work upon a design of manifesting many otherwise interpreted passages of the new testament to be prophecies; of whom no less than the famousst of the modern Rabbies, *Menasse Ben-Israel*, (one time I made him a visit at his own house in *Amsterdam*) gave me this character, that he took him for the ablest person of the Christians. Those historical circumstances quarrelled with, in Christ's parables, are like the feathers, that wing our arrows, which though they pierce not like the head, but seem slight things, and of a differing matter from the rest, are yet requisite to make the shaft to pierce; and do both convey it to, and penetrate the mark. But nothing is thought more impertinent in the scripture than the frequent repetitions. But the learned need not to be told, that many things seem to the ignorant, bare repetitions, which yet ever bring along with them some light, or some accession; in that comparable to the stars, which, as like as they seem to vulgar gazers, are by the skilful astrologer taught to contain, under that colour and figure common to them all, very peculiar and distinct influences. I here also consider, that in all languages there are some customary geminations and expressions, which, though to strangers they appear superfluous, if not absurd, to the natives, and in the propriety of that speech, are not only current, but oftentimes emphatical. I find withal, that there is scarce any of these seeming impertinencies, of which a learned and judicious expositor cannot assign a pertinent cause or reason; and I consider too, that the books of scripture being indited, not all at once, but at very several and distant times; (according to the known saying, that *Nunquam satis docetur, quod nunquam satis discitur*) the repetition of the same sins and errors required that of the same menaces and dissuasions; whose frequent enforcing, serving both to attest and convince the sinner's obstinacy, was not a bare repeating, but such a redoubling as we are fain to use, to drive in a nail to the head; (and the words of the wife are, in the wise man's words, *As nails fastened by the masters of assemblies*) where though in all the renewed strokes the busy hammer gives, the act be still the same, yet is no blow superfluous; the number of them serving to compleat their operation. They that in perusing books have the learning and skill to strip them, of what oratory or stealth hath dressed and disguised them in, will easily discern most of them to be but varied repetitions: which for my part I find differing from those of scripture, but in that the latter do in the same words generally comprize new matters, whereas the former usually present us stale matter in new words. And I consider further, that our own sad experience showing us, that there is no single text of scripture, that subtler hereticks sophistry cannot plausibly enough elude; the Holy Ghost foreseeing this from the beginning, hath mercifully and wisely provided, that the fundamental truths of faith and manners should be held forth in so many places, and in so much variety of expressions, that one or other of them must unavoidably intercept those evasions, and escape those misconstructions, that sophistry may put upon the rest. Which providence alone hath preserved many articles from the attempts of hereticks; making them both blush to question, and despair to disprove a truth attested by more than two or three witnesses; and giving orthodox believers the satisfaction of having their anchor tied to a *threefold cord, which is not easily broken*. Most of the Bible's repetitions (or inculcation rather) teach us something or other untaught before; and, as in *Pharaoh's* vision, though both the ears and the kine signified the same thing, yet *Joseph's* interpretation shows, that neither was superfluous; even those few, that teach

us nothing else, teach us at least the importance (or some other attribute) of those repeated points we were taught before. And I scruple not to compare the expressions of the scripture to a rose, where though so many leaves nearly resemble each other, there's not one of them, but contributes to the beauty and perfection of the flower.

The sixth OBJECTION.

I AM not unacquainted with the קרי *Keri*, and the כתיב *Cethib*; nor the תקין ספרים *Tikkum Soph'rim* in the old testament: nor yet with the *Variae Lectiones* (especially those of the Eastern and Western Jews, as they are called) taken notice of by modern criticks in the Hebrew text of the old, as well as in the Greek of the new testament. I am not neither altogether a stranger to the difficulties to be met with, in making good the citations we find made of divers texts of the former of those sacred instruments in the latter: in which they seem not unfrequently to differ much from what we find extant in the ancient testament, as to the words, and sometimes too as to the sense. These things, I say, though by some much urged against the scripture, I am not ignorant of. But I think it not fit to consider them in this place; not only, because those, that are much better qualified for such a work than I, have done it already; but because these objections relating rather to the truth or the authority, than to the style of the scripture, the nature of my present task does not oblige me to examine them. Especially, since I have already said something of them, and may say more, in what I write on the behalf of the Christian religion. And it is upon these grounds, *Theophilus*, that I also decline at present the consideration of what is wont to be objected, as if there were a great many self-contradictions to be met with in the scripture. Only I shall in the mean time invite you to take notice with me, that it is not oftentimes so much the various aspects of the texts, as the divers prepossessions and interests of the expositors, that make books seem replenished with interfering passages and contradictions. For if once the theme treated of do highly concern men's interests, let the book be as clear as it can, subtle and engaged persons on both sides, perusing it with forestalled judgments of biased passions, will be sure to wrest many passages to countenance their prejudices, and serve their ends, though they make the texts never so fiercely fall out with one another, to reconcile them to their partial glosses. Of this I might produce an eminent instance in *Aristotle's* physical writings, alledged by so many dissenting sects of school-men to countenance their jarring opinions; the injured *Stagyrite* (employed as second by every one that quotes him) being by every sect brought to fight with his antagonists, and by them all to give battle to himself. Thus do the dissenting sects of Mahometans quarrel as well about the sense of their Alcoran, as we do about that of our Bible; and make the one as much a nose of wax, as the Romish catholicks say we make the other. Which brings unto my mind, that not only the δυσνόητα τινα, the *some things hard to be understood* in St. Paul's epistles, but also the λοιπαι γραφαι, the *other scriptures* are by St. Peter said to be by the *unlearned and unstable wrested to their own destruction*. When a sober author finds an impartial reader, who takes his words in their genuinely obvious acception, wherever the context doth not manifestly force another on them, (in which then the reader acquiesces) the writer is easily understood. But when nimble and forestalled wits peruse an author, not to fit down with his sense, but to make him speak theirs, (whether it be his own or no) and giving themselves the pains and leisure of considering all the possible acceptions of a word or phrase, and the liberty of pitching upon that which best serves their present turn, allow themselves to conclude, that because it may signify so and so elsewhere, therefore it does so here: an author must be much warier than *Homer* and *Virgil*, whom *Eudocia* and *Alexander Ross* have made evangelists, to keep

Of contradictions presumed betwixt passages of scripture.

2 Pet. iii. 16.

John vi.
60, 66, 68,
69.

John i. 50.

his words from being tortured into a confession of what was never in his thoughts. And a very pregnant instance of this truth we may observe in the law of our land, whose very end being to prevent or abolish strifes; and which being written so punctually and expressly, and in so peculiar and barbarous a style (clogged with super-numerary repetitions) that nothing but their been conducive to so good an end could make it supportable; is yet by mens concerned wits so misconstrued and perverted, that not only in private mens cafes, we see the judges so puzzled, that suits oftentimes out-last lustres; but the prince's party and the subject's kill, and execute one another; and (as charity tempts me to presume) think they may do so by the law, and do so for the law. In this belief, that we often impute to the scripture our own faults and deficiencies, the instances of those anti-scripturists, I have conversed with, have very much confirmed me: though I have still esteemed, that the best as well as the shortest way, is not to wrangle with them about every nicety, where the defeat of their objections gives us no victory over incredulity, and by but evidencing the scripture's not being either false or absurd, can serve but to justify our reverence to them, not to impart it; but by solidly asserting the divine origination of the scripture, reduce men to ascribe their scruples to the true cause; and persuade us to the temper of the Apostles, who, when Christ had uttered a hard saying, which so unsettled many of his disciples, that they deserted him upon it; though (their gross misapprehensions of numerous other much less obscure passages will easily persuade us) they relished it not aright, yet would by no means forsake him for their master, because, says their spokes-man, *Pater, thou hast the words of eternal life, and we believe, and are sure, that thou art the Christ, the Son of the living God*: teaching us, with one grand and comprehensive truth, to silence particular scruples. And one thing would not be unworthy our objectors considering; that the truth and authority of the scriptures, and consequently their not being contradictory to themselves, hath (as we may elsewhere have occasion to manifest more at large) been immemorably believed by the learnedest men in the world; many of whom may be very reasonably supposed to have examined opinions without any other concern in their inquiries than that of not being deceived; or any other end than that of finding out the truth; and most of whom, though by their sedulousness and their erudition they discovered difficulties in the Bible, that our quærists could never have dreamed of; yet did they all conclude the belief of the scriptures grounded on as much reason, as is consistent with a due latitude for the exercise of faith: which possibly needs some dimness or reluctance in the understanding, to be an acceptable virtue of the will; (faith and the twilight seeming to agree in this property, that a mixture of darkness is requisite to both; with too refulgent a light, the one vanishing into knowledge, as the other into day). And now faith thus casually presents her self in my way, it will, perhaps, not be impertinent to observe, that Christ often deals with new believers, as he is recorded to have done with *Nathaniel*; for as when that guileless *Israelite* had acknowledged him the *Messias*, upon the bare evidence of his having been discerned by him under the fig-tree, our blessed Saviour tells him, *Because I said unto thee, I saw thee under the fig-tree, believest thou? Thou shalt see greater things than these*; (which in the next verse he proceeds to mention) so when men once have embraced the persuasion of the scripture's being divinely inspired, that faith is a thing so acceptable to God, that he often discovers to them, to confirm them in their belief, arguments much clearer than those that induced them to it; and convinces them of the reasonableness of having submitted their reason to him that gave it them. And (as if there were mysteries, in which faith doth more prosperously make way for understanding, than that is set awork

to introduce faith) it happens to them, as it did to the two blind men mentioned in the gospel, in whom our Saviour first required faith, and (having found that, he) then opened their eyes. Matth. ix. 27, &c.

The seventh OBJECTION.

FROM the (not long since mentioned) frequent repetitions to be met with in the scripture, and from the unusual method, wherein the author of it has thought fit, that the divine truths and precepts should be extant there, divers have been pleased to take occasion to criminate the Bible, as if, its bulk considered, it were but a barren book; wherein instructions are but sparingly scattered, in comparison of what is to be met with in divers other writings, where repetitions are avoided, and more of useful matter is delivered in fewer words. And hence it is (say these objectors) that many persons unquestionably religious chuse rather to study other books of devotion and morality, as containing more full and instructive precepts of good life.

I MIGHT answer this allegation by representing, that the several particulars, whereon the accusation is grounded, having been already examined by me, I need not say any thing distinctly to this accumulative charge. But because I would not only defend my veneration for the scripture, but persuade it, I shall on this occasion offer two or three things to consideration.

ALTHOUGH then the scripture were less replenished with excellent doctrines, and were but, as well as the best of other books, like mines, in the richest of which the golden ore is mingled with store of precious materials, (and needs a laborious separation from them) yet sure it would, like those mines, deserve to be carefully digged in: and it will become the grateful Christian's zeal to imitate him in the parable, who having found *a treasure hid in a field*, stuck at no price within his power, to purchase the whole field for the treasure's sake. Mat. xiii. 44.

BUT, God be praised, this is not the case; for it is only our ignorance, our laziness, or our indevotion, that keeps us from discovering, that the scripture is so far from being, as the objectors would have it, a wilderness or a barren soil, that it may be much more fitly compared to that blessed land of promise, which is so often said in scripture to be flowing with milk and honey, things useful and delightful; if not to paradise itself, of which, it is said, that there *the Lord God made to grow every tree, that is pleasant to the sight, and good for food; the tree of life also in the midst of the garden.* Gen. ii. 9. And indeed, as the author of it was omniscient, so experience has taught, that he has so much expressed himself to be so in the scripture, that the more knowing its pious studiers have been, the greater store of excellent truths they have met with in it; the scripture being indeed like heaven, where the better our eyes and telescopes are, the more lights we discover. And that this may not appear to be said *gratis*, let us consider, that a book may be instructive as well by teaching its readers speculative truths as practical ones, and that Christians ought as well to know what God would have us think of him and his works, as what he would have them do. Now as it is past question, that there are no speculative truths, of so noble and elevated a nature, as those that have God himself for their object; so there is no book, from whence there is so much to be learned, as there is from the Bible, of the nature, and even the thoughts of God, and of those deep mysteries, into which, as I formerly noted from *St. Peter*, the angels themselves are greedy of prying. 1 Pet. i. 12. Nay, there is no other book whatsoever, that teaches us any thing at all, concerning divers of these sublime subjects, that may be safely relied on, save in what it is beholden to the scripture for. So that we cannot without an extreme injury look upon that book as barren, which alone contains all those revealed truths, which are of so noble and precious a nature, that we justly prize

the composures of heathen philosophers, and other authors, for being enriched with guesses at some few of them, though much embarrassed by the alloy, whereto the truths, conjecturally delivered, are made liable from the imperfections of writers, always fallible, and, for the most part, in some degree or other, actually erroneous. But of this more perchance elsewhere. Wherefore I shall now add, that whereas those we reason with, are pleased to prefer other books of morality and devotion before the scripture, in reference to good life; they would probably be of another mind, if they duly considered, that to engage men to live well and holily, there is much more requisite, than barely to tell them, that they ought to do so, and how they should do it. For since to lead a life truly virtuous requires in many cases, that we deny and overcome our natural appetites and inclinations, and requires also constancy in a course, that is confessedly wont to be attended with many hardships and dangers; it is not sufficient, to engage a man to a good life, to give him precepts of it; which do not so much (what is yet the main thing in this case) make men willing to conform to such precepts, as suppose them so. And he, that can do no more, does far less than him, who, besides the rules of good life, presents men the highest, and the most prevalent motives to embrace piety and virtue, and the most powerful dissuaves from all that is wicked; by proposing to us such rewards and punishments, and satisfying us, that we ought, according as we behave ourselves, to expect either the one or the other; as to convince us, that we cannot be either wise or happy, but by being good, nor avoid the greatest of miseries, but by avoiding vice. Now, as we shall see anon, that as to the precepts of good life, the Bible is not unfurnished with them; so as to that most operative part of the way of teaching good life, the proposing of the most prevalent motives to good, and the most powerful dissuaves from evil; not only no other book does, but no book not inspired, can perform, in that kind, any thing near so much as the scripture alone. Since we have not the same reason to believe any mere man, as we have to believe God, touching those rewards and punishments, which he reserves after death for those, that conform to, or disobey his laws; these being matters, which (whatever philosophers and other learned men may have thought to the contrary) depend upon his free will, and consequently are not to be explicitly known but by his revelation; which he has not, that appears, vouchsafed us in any other book than the scripture. And therefore it is not to be wondered at, that St. Paul should ascribe it to our Saviour Christ, *That he had brought life and immortality to light through the gospel*. And whereas hope is that spur, without which men do scarce ever cheerfully undertake, and resolutely go through things, much less difficult and dangerous than those, which a virtuous course of life is wont to expose men to, St. Peter makes a Christian's highest hope to depend upon a revealed truth, where he gives thanks to God for having, according to his abundant mercy, begot us to a lively hope, by the resurrection of Jesus Christ from the dead. And what influence such a knowledge of God and Christ, as, if we have it at all, we must owe to the scripture, and such hopes and promises, as none but God himself, or those he sends, can give a wary and intelligent person, may have upon good life, you may guess by that other passage of the same Apostle, where not only he mentions God's having according to his divine power (or efficacy) given unto us all things, that pertain unto life and godliness, through the knowledge of him, that hath called us to glory and virtue, but also immediately after speaks of our being made partakers of the divine nature, and escaping the corruption, that is in the world through lust; by those exceeding great and precious promises, that are given of God unto us. So that although the scripture did not expressly give us such moral documents as ethical writers do, and taught us good life, but by acquainting us with what God has revealed in those writings concerning himself, and by convincingly proposing to us those highest inducements to embrace a good, and shun an evil life, which (though reason may perchance

2 Tim. i.
10.

1 Pet. i. 3.

2 Pet. i. 3,
4.

perchance make some weak and confused guesses at them) revelation only can make examining men confidently depend upon: if, I say, the scripture did no more than thus engage us to resolve upon a good life, leaving us to derive the particular precepts of virtue from the inward dictates of the law of nature, and the exercise of our own reason, (which two together may well teach us almost as much as ethical books are wont to teach, of really and considerably useful) the scripture ought yet to be esteemed a most instructive book in reference to good life. As in effect we see, that the writings of no philosopher or orator ever made any thing near so many persons so virtuous, as the new testament, though but a pocket book, has been able to do; especially in those primitive ages of the church, when those that received that book were less diverted from it, than since they have been by the reading of others. The moon may in clear weather lend a gardener light enough to dig, and manure his orchard, and perhaps to prune his trees; but none will say, that the moon does as much contribute to his labouring to produce fruit as the sun; since this nobler planet not only affords him light to work by, and a comfortable warmth whilst he is working, but animates him by the hopes he cherishes upon the sun's account, that in due season his diligence and toils shall be rewarded. The application is too obvious to need to be insisted on.

BUT though upon the fore-mentioned accounts alone, the scripture would deserve to be looked upon as highly conducive to the practice of piety and virtue; yet it is far from being true, that it is destitute of such moral documents, which it needs not, to deserve to be looked upon as a book very instructive in reference to good life. For there being two sorts of virtues requisite to an embracer of the gospel, which have been conveniently enough called, for distinction-sake, the one Christian, and the other moral or ethical; I suppose it will not be doubted, but that the rules of those virtues, that are properly Christian, must be sought for in the scripture, that being acknowledged by protestants, to have such a sufficiency as to matters of meer revelation, (which restriction too many do inconsiderately enough leave out) that in matters of that nature, divines often do, and in many cases may, argue negatively, as well as affirmatively from the scripture; which eases us of many things obtruded as duties, merely by its not, either expressly, or by consequence, imposing them upon us. So that as to things of this nature, there is such a fulness in that book, that oftentimes it says much by saying nothing, and not only its expressions but its silences are teaching, like a dial, in which the shadow as well as the light informs us. Nor must we think, that the Bible is destitute of the best sort of such precepts, exhortations, and dissuatives, as we prize in ethical books; because they are not expressed and ranged in the Bible, as they are wont to be in systematical composures; for not only there is extant in the scripture, to them that know how to constellate those lights, a very excellent body of moral precepts; but there are likewise scattered the forciblest motives to the several duties, and the most retracting dissuatives from the contrary vices. And truly, it hath long lessened my esteem of our heathen morals, that ethicks being but the doctrine of regulating our passions, and directing our faculties, in order to the attainment of felicity, they have been hitherto handled by those, to whom the nature of the faculties and passions of the mind was but very little known: whereas to the author of the scripture morals, the frame and springs, and faculties of our souls, being intuitively and most perfectly known, the most proper and powerful ways of working on them, cannot be unknown to him: and then certainly, one unacquainted with the trade will be much less likely to mend a watch, that is out of order, than a watch-maker. And indeed, even in reference to that other sort of virtues, which are wont in the more confined sense of the word to be called moral, there

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are I know not how many excellent notions and directions, relating to them, dispersed up and down in the scripture; though by reason of their not being drawn up by themselves, and of their being mingled with other matters, they are not so readily taken notice of by ordinary readers. Whereas, those studious perusers, that search the scriptures with a due diligence and attention, are not only wont easily enough to descry the moral counsels and prescriptions over-looked by the other readers; but take notice of many excellent documents, that are plainly enough intimated or hinted there to knowing and diligent perusers, though not clearly and expressly enough to be found of those, that think them not worth seeing.

WHEREFORE, as to those religious persons mentioned in the last proposed objection, I cannot but think, that by neglecting the scripture for ethical composures, or even books of devotion, they as well wrong themselves as the scripture: and therefore I shall take leave to think the worse, rather of the practice of the men, than of the book of God. Scarce any thing has given me a favourabler character of *Luther*, than his wish, that all his books of devotion were burnt, when he once perceived, that the people's fondness and over valuation of them produced a neglect of the study of the Bible; to which you shall find, *Theophilus*, that the best of that nature being compared, are but (not to draw to our present purpose that of *Seneca* to his mother; *Paribus intervallis omnia divina ad omnibus humanis distant*) like the stars compared to the sun, whose emanations confer on them their lustre, but whose presence drowns it. For though I deny not books of devotion a due degree of praise and usefulness, yet I refuse them the superlative degree of either; and since the writers of the best of that kind of composures, either steal their best things from, or acknowledge that they borrowed them of the Bible; I would not have Christians neglect the fountain for the streams, and unwisely, as well as unthankfully, elect to read God's word, rather in any book than his own; in which, to encourage us to study the precepts of a virtuous and holy life, we have such peculiar and encouraging invitations.—Saint *Paul* seems to make it the (end and the) result of the several usefulnesses he attributes to the scripture, *That it can make the man of God perfect, thoroughly furnished unto all good works; and is able*, (as he speaks a little higher) *σοφίαν εἰς σωτηρίαν, to make us wise unto salvation*. There are indeed many excellent instructions given to us in other books; but they giving us directions, only towards the attainment of the advantages, conveniences, and ornaments of life; the ignorance of them only makes us miss those particular ends, whereto they give addresses, or whereof they facilitate our pursuits; but the knowledge, whose acquit, or neglect, imports endless joys or torments, we need seek only from the scripture: a Christian to understand the duty of his faith and life, needing to understand no other book than the Bible; though indeed to understand the Bible well, it is ordinarily requisite, that a pretty number of other books be understood. Christians then have reason to study most that book, which understood, all others are needless to salvation, and which ignored, they are insufficient. If Saint *Peter's* vision had been a reality, he would scarce, hungry as he was, have ranged abroad to hunt in this desert or that forest for game, when he had a vessel let down to him from heaven, containing in it's self all manner of four-footed beasts, and other objects of appetite, attended with a commanding invitation from heaven, *Rise, Peter, kill, and Eat*. So when God sends us from heaven in one volume, a, at least virtual, collection of all those divine truths and holy precepts, others scatteringly and sparingly glean out of human books; the Christians cannot but prize a book so comprehensive, which by making it safe for him to ignore others by so merited an *Autonomasia*, wears the title of *the book*, (for so the Bible signifies in Greek, as the Hebrews call it *Mikra*, which by excellence signifies *what's to be read*.)

Seneca de
Cons. and
Helviam,
cap. 9.

2 Tim. iii.
17.
Ver. 15.

Acts x. 11,
12, 13.

read.) — There are precepts enough of virtue, and motives enough to conform to them, held forth in the Bible, if the contents of that divine book were believed and considered as they ought to be. It is a mistake to think, that a large system of ethicks, dissected according to the nice prescriptions of logick, and methodically replenished with definitions, divisions, distinctions, and syllogisms, is requisite or sufficient to make men virtuous. Too many of our moralists write, as if they thought virtue could be taught as easily, and much in the same way, as grammar; and leaving our rational motives to virtue, and determents from vice, with other things, that have a genuine influence on the minds and manners of men, they fall to wrangle about the titles and precedencies of the parts of ethical philosophy, and things extrinsic enough to vice and virtue; they spend more time in asserting their method, than the prerogatives of virtue above vice; they seem more solicitous, how to order their chapters than their readers actions; and are more industrious to impress their doctrine on our memories than our affections, and teach us better to dispute of our passions than with them. Whereas, as the condition of a monarch, who is possessed but of one kingdom or province, is preferable to that of a geographer, though he be able to discourse theoretically of the dimensions, situation, and motion, or stability of the whole terrestrial globe; to carve it into zones, climates and parallels, to enumerate the various names and etymologies of its various regions, and give an account of the extent, the confines, the figure, the divisions, &c. of all the dominions and provinces of it: so the actual possession of one virtue is preferable to the bare speculative knowledge of them all. Their master *Aristotle* hath herein been more plain, and less pedantick; who (by favour of his interpreters) hath not been nice in the method of his ethicks. And indeed, but little theory is essentially requisite to the being virtuous, provided it be duly understood, and cordially put in practice; reason and discretion sufficing, analogically, to extend and apply it to the particular occurrences of life; (which otherwise being so near infinite, as to be indefinite, are not so easily specifiable in rules:) as the view of the single pole-star directs the heedful pilot, in almost all the various courses of navigation. And the systems of moralists may (in this particular) not unfitly be compared to heaven, where there are luminaries and stars obvious to all eyes, that diffuse beams sufficient to light us in most ways; and as I, that, with modern astronomers, by an excellent telescope, have beheld perhaps near a hundred stars in the *Pleiades*, where common eyes see but six; and have often discerned in the milky-way, and other pale parts of the firmament, numberless little stars generally unseen, receive yet from heaven no more light useful to travel by, than other men enjoy: so there are certain grand principles and maxims in the ethicks, which both are generally conspicuous, and generally afford men much light and much direction; but the numerous little notions, (admit them truths) suggested by scholarship to ethical writers, and by them to us, though the speculation be not unpleasant, afford us very little peculiar light to guide our actions by. When I remember those ancient heroes, that have ennobled secular, and are ennobled by sacred story, and whose examples suggested the precepts of virtue, before there were any written ones to conform to; I am tempted to say, that virtue was scarce ever better practised, than whilst men had not yet talked of the definition of it: (as many an alchymist begs with rare notions of the nature of gold, which fills the coffers of merchants, that never saw mine nor furnace.) The grand precepts of morality are fruitful seeds, which, industriously cultivated, will bring forth fruits still affording other seeds. And as for the motives to pious, and dissuasions from sinful practices, though out of the many voluminous books of morality, there may be divers collected, not extant in the Bible; yet may a dextrous

dextrous reader find in that heavenly book many more invitations to virtue, and determents from vice, than most men are aware of; and some of them of an importance, that renders one of them as much more considerable than many ordinary ones, as one fair pearl out of a jeweller's shop out-values a score of those little pearls, that druggists sell by the ounce, or doth comprize many inferior inducements, (which wise men judge not of by tale, but value) as a piece doth twenty shillings. And though human authors do often in their parenetical treatises allow themselves to be lavish in ornaments, to expatiate into amplifications, and to drain common-places; yet whilst they want an intimate admission, all these are too often unable to reform, I say not those that read them, but even those that write them: whereas the experience of the primitive and heroical ages of the church does gloriously manifest, that the inducements and dissuaves held forth in the Bible, though destitute of those embellishments and advantages, where they are conscionably entertained, and seriously pondered, are sufficient to raise virtue to a pitch philosophy durst scarcely aim at. Nor indeed is the number great of pertinent and rational incitements, or determents, relating to virtue; and in discourses, that have them for theme, how far soever the bows may extend, yet generally the knot lies in a little compass: and the analyser, that shall crack many of those composures, having severed the shells, shall find their kernels to be much alike. What this writer compares to one thing, that writer likens to another; those ungrateful persons to God, that one resembles to swine, who eat the acorns without ever looking up to the tree they fall from, another compares to cattle, that drink of the streams, without considering what fountain they flow from; these but present us several dresses of virtue and vice, where though the novelty and variety of habit serve to engage attention in all, and want not influence (at least) upon easy and flexible natures, yet in considerate and discerning persons, they alter not much the notion, under which the qualities themselves are entertained. Nor will such be apt to quarrel with the author of the scripture; because the motives and dissuaves extant there are many of them old and known, or frequently repeated; the efficacy of them being so too. Were it not strange, a physician should decline exhibiting of mithridate, because it was a known medicine, and famous for its cures many ages since? Doth bread less nourish us, or is it less used, because it was (as men suppose) contemporary to *Adam*, and the most common food of all nations in all ages? And (as to the repetition of the same allegation and inducements, as often as men's condition returned to need them) the paucity of ponderous considerations in the ethicks often necessitating either (disguised perhaps, yet) repetitions of the same, or the substitution of those, that must be much inferior to be new; such persons as little admire, that reiterated employment of the same truths, as they would to see a soldier use a sword, though he, and legions many ages before him, have constantly made most use of that weapon; or a general encourage his engaging soldiers by representing to them honour, duty, spoil, necessity, and those other known topicks used by himself at the head of his army, as often as he had occasion to lead it on to fight. To all this I am invited by this occasion to subjoin, that upon the score of God's being both an omniscient spirit and the supreme law-giver to the whole creation, the same truths, counsels, exhortations, dissuaves, &c. oftentimes have, and always ought to have, another-guess efficacy and prevalence on a Christian reader, when he finds them in the scripture, than if he should meet with the same in the books of heathen moralists, though learned and eloquent. And certainly, those, that with such reverence read the writings of those great wits of antiquity, that have made the greatest discoveries of truth, because they believe them to have been endowed with very illuminated intellectuals, ought to pay them, and a book published by

by an omniscient enditer, a reverence somewhat proportionate to the disparity of their authors, since men (as *Elibu* speaks in *Job*) are but of yesterday, and know little or nothing. A wary person reads the wisest authors, with a reflection, that they may deceive him by being themselves deceived; and undergoes a double labour, the one in investigating the meaning, and the other in examining the truth of what they deliver: but in the Bible, we are eased of the latter of these troubles; for if we find the sense of a text of scripture, we cannot miss a truth, being never deceived by that book, but when we deceive our selves by presuming we understand it, when indeed we do not. I am otherwise affected to find the vanity of the world proclaimed and depreciated by him, that enjoyed all the delights and glories of it, than when I meet with the same truth from some beggarly Cynick, that never was admitted to taste those luscious and bewitching pleasures, and needs no great philosophy to despise a world, he judges of by the scant share the narrowness of his condition allows him of the joys of it, and of which (consequently) his criminations should as little move, as a blindman's of a black-moor; whom though he may (perchance) truly style ugly, yet he were of a somewhat easy faith, that should think her so, barely upon the testimony of so incompetent a witness. Thus when God himself is pleased to reveal, what is vice or virtue, sublime or despicable, truth or falsehood, happiness or misery, I have another-guise acquiescence in his decisions, than in the same met with in an human author, who having necessarily frailties and passions, is both obnoxious to mistake, and capable to deceive. And therefore it is no wonder, that the slighting of God's dictates should receive an aggravation upon the score of their being his: as, our Saviour gave the precedency of the Ninevites converted by *Jonah* to them, that repented not at his preaching, because he was a greater than *Jonah*. And therefore, though I have formerly been no very negligent peruser of books of morality; yet knowing, that they have a power but to persuade, not to command, and that the penalties of sin or death are not inseparably annexed to the disobedience of their prescriptions, I confess, I often find my self but faintly wrought on by them. For I must acknowledge, that frequently assuming the liberty of questioning the reasonableness of what human writers (whether philosophers or fathers) are pleased to impose upon us; I find those specious and boasted allegations, the apothegms of the sages, the placits of the philosophers, the examples of eminent persons, the pretty similes, quaint allegories, and quick sentences of fine wits; I find all these topicks, I say, such two-edged weapons, that they are as well applicable to the service of falsehood, as of truth, and may by ready wits be brought equally to countenance contrary assertions. And really, most moralists, except in those few duties, that nature herself hath foretaught us, to a man, whose restless curiosity leads his enquiries to all times and nations, will appear little other than fencers with wit, (I mean those that have any;) for each of these popular topicks is such an unsolid or uncertain foundation, that one man can build little on it, that an equally able antagonist may not with as specious probability overthrow; and I fear, most of us have but too often found our corruptions sophisters enough to elude any such thing, that pressed that as a duty, which they had no mind we should perform. But when I find any thing enjoined in the scripture, my consciousness to its being imposed by that father of spirits, (who has both right to enact laws, which must be therefore just, because he enacts them, and power to punish the transgression of them, with no less than eternal death;) I then leave roving, and see where to cast anchor. I think it my part without disputing them to obey his orders, and acquiesce more in that imperious *ὁ κύριος ἔφη*, Thus saith the Lord, than in a whole dialogue of *Plato*, or an epistle of *Seneca*. I therefore love to build my ethicks (as well as my creed) upon the rock, and esteeming nothing but

Mat. xii.
42.

Heb. xii.
9.

the true, proper, and strict sense of the scripture, (and what is convincingly deducible from it) to be indispensably obligatory, either as (in matters of mere revelation) to faith or practice; it is no wonder, if I study God's will most in that book, wherein alone I think it revealed; and, truly, finding in my self no motive more justly prevalent to obedience, than his right to exact it that requires it, few men are more ready than I, in distinguishing what indeed God says from what man would make him say. And if I allow my self such liberty to discern the text from the gloss, in the writings of our vulgar interpreters, (of most of whose comments, for reasons prosecuted into another paper, I am no great idolater) and even of the fathers of the church; I hope I shall not need to tell *Theophilus*, that in all other moralists I like the freedom to like or disapprove, as upon examination my impartial reason relishes them, or that I frequently fear their harangues will hardly pass for demonstrations, with those wary testers, that like not to be cheated, so much as into virtue, but chuse to act as rational or Christians, as well in relation to the inducements, as to the nature of what they do.

AMONGST the thirteen articles of the Jewish creed, one acknowledges the very expressions of the law (or pentateuch) to have been inspired by God. That saying of the Rabbins is not altogether so hyperbolical, as a perfunctory reader would imagine, that upon each title of the law whole mountains (of doctrine) hang. I shall not mention, as any proof of this, the strange mysteries they fancy in the strange accenting of the ten commandments in the original, since their soberer doctors have in free discourse confessed to me, that it is as much a riddle to them as us. Nor shall I insist upon the Jews reducing the whole law to 613 precepts, affirmative and negative, according to the number of the letters of the decalogue; thereby insinuating that all the laws, that regulate man's duty, are virtually or reductively comprized there. Although this Rabbinical notion, (not to call it whimsey) be in such request among them, and so known to those, that are any thing conversant in Jewish authors, that I have sometimes suspected, that the conceit entertained by so many Christian divines, that all the precepts, that relate to any part of the whole duty of man, are but just consequences deducible from the decalogue, had its rise thence. But I shall not, as I said, ground my opinion of the pregnant instructiveness of the scripture, upon such questionable, not to say altogether proof-less, conceits. That which may better persuade a considering man, is, that besides those more resplendent and obvious truths, wherewith the scriptures do evidently abound, there are many instructions exhibited, many truths asserted, many errors confuted, and many mysteries hinted, in the very expressions of holy writ, to an inquisitive and concerned peruser, which a heedless vulgar reader is not wont to take notice of. God, who in the scripture is said to cover himself with light as with a garment, justifies that expression in the scripture, where (as the first words, that he is recorded to have ever spoken, were יְהִי אוֹר *Yehi-or, Let there be light*) the very words and phrases, that cloath the sense, are not alone emphatical, but oftentimes mysterious. The Apostle assures us, *whatsoever things were written*, even in the old testament, *were written for our learning*; but yet, besides those many particular sentences of the Bible, that are not destitute of instructions, there are some so pregnant with them, that we may easily find this difference betwixt them and human writings, that those first mentioned contain more matter than words, and the other more words than matter. Nay, many of the very flowers of rhetorick growing there have (like the marygold, that in hot countries points at the sun) a virtue of hinting the usefulest and the sublimest truths; the Bible being in this like the tree of life, (flourishing in the *New Jerusalem*), which not only afforded seasonable fruit, but of which the very leaves were for the healing of the nations. As for

Psal. civ.

2.

Gen. i. 3.

Rom. xv.

4.

Rev. xxii.

2.

for those, who have in this and the last age made bold to depreciate the old testament, by pretending, that to Christians the new is sufficient; I am at present apt to think, that the doctrine of the gospel, together with the light of nature, (which it excludes not, but rather supposes) contains all those duties, which are absolutely necessary to be performed by all Christians, in order to salvation. And that consequently, many divines, both Catholicks and Reformed, do inconsiderately enough praise many things enacted in the old testament, as laws properly so called, which are not now, upon the score of their being there enacted, obligatory to us Christians, nor perhaps ever were to any, but the Jews, and some kind of Jewish proselytes. But I think withal, that though it be hard to shew, that any thing is a necessary duty to Christians, in the sense above declared, if it cannot be shewn to be so, either by the new testament, or the light of nature: yet not only there are many particulars relating to such duties, of which the old testament may excellently assist us to give ourselves a more distinct and explicate instruction, than is easy to be collected from the new; but of the mysteries of our religion, there are many things delivered more expressly, or more fully, in some passages of the old testament, than in any of the gospel, as I could easily evidence, if I thought it requisite. So that the use of it is very great, as to the *credenda* in divinity, though not perhaps absolutely necessary as to the *agenda*. But I consider further, that both the matters and the expressions made use of in the old testament are so very frequently, and, almost upon all occasions, related to in the new, (as if the wisdom of God were like rivers and seas, that affect to flow in the same channels themselves had made before) that there is scarce a page of the latter, to the better understanding of which the study of the former is not either absolutely necessary, or at least highly useful. Should God be pleased to instruct us, as he did *Jonas*, by the shadow of a weed, it were our duty to acquiesce: how much more then, when he vouchsafes to speak to us in almost as glorious a manner as he did to *Moses*; in a scripture, that hath such resemblances to the sanctuary, which contained the law of God, exhibited the mercy-seat, (the type of Christ) and wherein the two golden cherubims, like the two precious and harmonious testaments, looked towards one another, and both towards that mercy-seat, that typified the Messiah? We should therefore, not only with acquiescence, but gratitude, look upon God's having appointed the scripture to be the light, in which his spirit regularly shines upon his church; since the luminary is as well refulgent, as the choice of it his, whose blessing can prosper any means of grace, as without his blessing no means of grace can prosper.

AND, *Theophilus*, since among those, that are so far mistaken, as to postpone the study of the Bible to that of some applauded books of morality and devotion, there are not wanting divers persons, otherwise eminently religious; I hope you will easily excuse me, if, for fear their example should prove a temptation to you, and add to the discouragements you must expect from the darkness of some texts, and the opposition, that will be given you, especially at first, by the grand enemy to the author and design of the scripture; I venture to superadd to all that I have said already, concerning these mens practice, that it is not only a commendable, but a much more improving custom, than it is by many thought, to read daily and orderly some set portion or chapters of the Bible; and, not to desist from that practice, though (as *Naaman* dipped himself six times in *Jordan*, without being cured) we should not perceive a sudden and sensible benefit accruing from it. For in diseases (bodily or spiritual) though the mouth be out of taste, and cannot relish what is taken in, yet wholesome aliments must be eaten, and do effectively nourish and strengthen, though they be then insipid, (perhaps bitter) to the distempered palate. We must, with the

Jonah iv.
6.

Exod. xxv.
16, 17, 18,
19, 20, 21,
22.

2 Kings v.
14.

Acts viii.
30, 31.

Luke ii.
50, 51.

See ver. 18,
19.

John xiii.
7.
Heb. xiii.
2.

Gen. xviii.
and Gen.
xix.

Acts vii.
38.
Rom. iii. 2.
James i.
17.
Tit. i. 2.

Mar. i. 26.

Rev. xiii.
12.
Rom. xvi.
20.

Mat. xiii.
19, 20, &c.
1 Pet. i.
2, 3.

Psal. cxix.
93.

1 Pet. ii. 2.
and else-
where.
Mat. iv. 4.

eunuch, read divers texts we understand not, when we read them; and though, at first, we be not able to penetrate the senses of some portions of God's word, we must at least make our faculties as hospitable to it as we can; and make our memories admit, and embrace it, till our understandings be grown up to do the like: it becoming the disciples of our Saviour, herein to imitate his holy mother, of whom it is written, that *they* (the blessed virgin and her husband) *understood not the sayings, which he spake unto them, — but his mother kept all these sayings in her heart;* and to think it may very well be, that, as our Saviour said to Peter, *What I do, thou knowest not now, but thou shalt know hereafter:* so, by the welcome he disposes you to give his word into your memory, he says to you, *What I say, thou knowest not now; but thou shalt know hereafter:* and the apostle's motive to hospitality, *Be not forgetful to entertain strangers, for thereby some have entertained angels unawares,* will, without being overstretched, take in the texts of scripture we are unacquainted with. For we may easily in them, entertain with *Abraham* and *Lot*, greater guests than we are aware of; and who, when their true condition appears, may recompence our entertainment of them, by showering blessings on us, and rescuing us from the company and destiny of the wicked. And sure, if the Pagans laid up, with awful reverence, those dark and squinting oracles, that came (at least many of them) from the prince of darkness, and father of lyes; we should blush to refuse attentive perusals, and lodging in our memories, to those *λόγια ζῶντα*, those *lively oracles*, those *λόγια τῷ Θεῷ*, *oracles of God*, who is the father of lights, and an essential truth that cannot lye. And the most ænigmatical texts we meet with, which seem meant purposely to pose us, we may make useful admonitors of our weaknesses, and take for welcome opportunities, to evince how great a reverence we pay God's word, upon the single score of its being so. Nor let those disturbances, with which the devil seldom fails to obstruct or discourage our first progress in a study so ruinous to his malicious ends upon us, deter us; for these are commonly but the throws and strugglings of Christ new-formed in us; or else like those horrid fits and outcries, which preceded the ejection of that unclean spirit mentioned in the first of *Mark*; such parting ceremonies being not unusual to the dislodging devil; who when he finds himself upon the point of being expelled, *hath great wrath, because he knoweth he hath but a short time.* And though the God of peace, however he will bruise Satan under your feet shortly, should for a while try us even with desertion in the study of the scripture; let us not, for all that, desert so improving a study, but resolutely persevere in the constant and faithful use of the means of grace: as the moon, when she suffers an eclipse, forsakes not her orb or motion, but, by continuing her unretarded course, regains the irradiations she was deprived of. We find the word of God compared to seed, (that deathless seed, by which Saint Peter saith, we are *born again*) and that, we know, may seem, for a long time, as well dead as buried in the ground, and yet afterwards spring and grow up into a plentiful harvest. Nor must our proficiency any more dispense with us from the being conversant with the scripture, than our frailties: *I will never* (saith the Psalmist) *forget thy precepts, for with them thou hast quickened me.* And indeed, the word of God is not to be used like active physick, taken once, that it may not be taken again; but 'tis compared to food, which indeed it is, of the soul; in which sense it may be literally enough said, *That man liveth not by bread alone, but by every word that proceedeth out of the mouth of God.* Now as our having fed never so well and heartily on excellent and nutritive meats yesterday, will not keep us from needing to eat again to-day, or to-morrow, and so daily, as long as we continue in these ruinous cottages of clay; so in spiritual refectons with full, without repeated meals, the soul will scarcely thrive. And as, generally, the more healthy

healthy and lusty men are, the frequenter and stronger appetites they have; so the best Christians, and (witness *David*) the greatest proficient in scripture-knowledge, have the keenest stomachs to this food of souls; and the vigorouslest piety, by a desuetude and neglect of it, is subject to faint and pine away. Nor have we just cause to repine at an engagement to assiduity in the scriptures; for there are not near so many things, that will require, as there are that will deserve and recompence a serious study in a book, where both the strict sense and the circumstances, and expressions that cloath it, are richly instructive: like that aromatical fruit, of which, not only the kernel is a nutmeg, but the very involving skin is mace. This in-exhausted fulness occasioned that panegyric precept of the Rabbies concerning the law; *הפוך ברה הפוך ברה ארי כולי ברה* Turn it over, and again turn it over, for all is in it: concurrently to which, the Jew, that translates the Arabian apothegms into Hebrew, thus pronounces; *There proceedeth not a true sentence out of the mouths of this world's wise men, that is not intimated in our law.*

תפוך
פוך
אחאנ.

Pick-
avoth.
cap. 5.

THE usefulness of divers texts is such, that we should not only have them in our possession, but in a readiness; and as *David*, distressed by his mortal enemies, took *Goliath's* sword from near the ephod, to wear it whithersoever he went; so Christians, prosecuted by ghostly enemies, should be diligent, not only to have an armory well furnished with spiritual weapons, but to wear this *sword of the spirit* always by their sides, to ward and thrust with, upon all occasions; without needing to depend upon any such thing as concordances, which often cannot be come by, and oftner, not soon enough to keep us from being foiled by the father, or the champion of lyes. But now, to engage us to grow ready scripturists, it is not only true, that as the texts of the Bible interchange light with one another, and every new degree of scripture-knowledge is not only an acquit of so much, but an instrument to acquire more; so is that book a theme so comprehensive and so fertile, that the last hour of a Christian's longest and industriousest life will still leave undiscovered mysteries in it: this, I say, is not only true, but it is also true, that the doctrines of it are of that importance, and find that opposition in our depraved nature, that even those truths, that require but few perusals to be understood, require many to be duly impressed; our preposterously partial memories, being rarely like quick-silver, wherein nothing will sink but (that pretiouslest of metals) gold; for that alone is heavier than the mercury. *The word of Christ* must not be as a passenger, or sparingly entertained in our minds, but must dwell there, and that richly: and the word, which *St. James* pronounces *able to save our souls*, he describes as a graff, which must not only be closely embraced by that, wherein it is to fructify, but must continue there, to bring the stock and graff to (if I may so speak) con corporate. And indeed we are so indisposed to admit, and so obnoxious to deface, religious impressions, that we need, during our whole life, be conversant with the precepts of leading it piously. — But it is scarce more faulty in, than incident to, the froward nature of man, to be ever quarrelling with God's method of prosecuting his intentions; and (as if he were wiser than his Maker) to criminate his conduct in his dispensations. Even that excellent person, the gloriouslest of virgins, and of mothers, whom all ages must deservedly call *Blessed*, incurred her divine son's reprehension, for an intimated offer to alter his purposed method in disclo sing himself. But God is too just to himself, and too merciful to us, to degrade (as it were) his omniscience so far, as to suffer himself to be swayed against the dictates of it, by such purblind and perverse tutors as we; his goodness concerns him too much in our instruction, to suffer him to let our fancies indite his word. To attain his own ends, he makes choice of his own means and instruments, without needing our purblind eyes in the election; and what with unfathomable wisdom he hath been pleased

Ephes. vi.
17.

Luke i. 48.
John ii. 3.
4.

Mat. xi.
16, 17, 18,
19.

1 Pet. i. 12.

Mat. xxvii.
42.

Luke xvi.
34.

pleased to contrive for man's instruction with a gracious, though often mis-understood constancy, he persists in. He knows, that many, who are disposed to cavil at the present contrivance or style of scripture, would be apt to take exceptions at any other: for some thing or other it must necessarily be; and the unimaginable diversity of humours, judgments and prepossessions is such, that as these now say, why thus, and not so? others would, in case of alteration, be as ready to ask, why so, and not thus? It is questionable, whether the Israelites were greater murmurers at *Pharoah* in *Egypt*, or at *Moses* in the desert: and the children complained of by their companions in the market-place have had either posterity or predecessors in all ages; which have been still of the disposition of those Jews, who imputed the more than prophets rigidity of virtue to the great enemy of that lovely quality; and the greater than *Solomon's* condescensions to the vices he designed them to destroy. But the great physician of mankind is too compassionate and wise, to let his distracted patients prescribe their own course of physick, or, to decline our fond and peevish cavils, shuffle or discompose those mysterious and profound contrivances; whose wisdom engages the attention, and exacts the wonders of those heavenly unclogged spirits, that are scarce more advantaged over us by their native abilities, than by the means they have of improving them. And therefore, our Saviour refused to descend from the cross, though they, whose malice served to fix him there, (the chief priests and scribes themselves) declared, that on those terms they would believe on him. And though we are (but too) apt to fancy, that we should be won to our duty, if it were taught or pressed in such or such a way; yet we may be pleased to remember, that it was one in hell, that would needs have another means than the scripture, of having sinners preached to; and one in heaven, that referring them to the scripture, declared, *That if men heard not Moses and the prophets, neither would they be persuaded, though one rose from the dead, to preach to them.*

IF I address what I write, not to so intelligent a person as *Theophilus*, but to promiscuous readers, I should add, to what I have said of the several exceptions against the scripture, a cordial advice to all, whose parts and leisure give them not a just hope of being able solidly to vindicate it either to themselves or others, to decline as much as they discreetly can, the listening to objectors or objections, of what sort, or under what disguise soever, against that heavenly book; especially, if proposed by plausible and insinuating wits. For it not being necessary, (nor indeed possible) for every private Christian, to know the opinions and reasons of all dissenters about the scripture, (no more than for every traveller to be a geographer;) nor requisite to the knowledge of the way to heaven, to know all those, in which they that miss it, wander; (as to learn the way from *Dover* to *London*, I need not learn those that lead not thither :) it is not prudent to run a very probable hazard of disquieting one's faith, and a not improbable one of subverting it, only to gratify a needless curiosity; an itch, which we are delighted to have scratched, but which is exasperated by being so. And frequently, though your design seem innocent, (as only to hear without believing, and please your self with something of wit and novelty) yet those conversations rarely enough prove harmless; and (as too frequent and sad experience proclaims) generally either abate a degree of your faith, or qualify some ardor of your love, or lessen your reverence for that matchless book, or put some strange and disquieting scruples into your thoughts, which it is much easier to confute than to silence. Wherefore, as in infectious times, when the plague reigns, physicians use more strictly to forbid the smaller excesses and inordinancies of diet, and the use of meats of ill digestion, or apt to breed any distemper; because every petty fever becomes, through the malignity of the air, apt to turn into the plague: so now, that anti-

anti-scripturism grows so rife, and spreads so fast, I hope it will not appear unseasonable to advise those, that tender the safety and serenity of their faith, to be more than ordinarily shy of being too venturous of any books, or company, that may derogate from their veneration of the scripture; because by the predominant and contagious profaneness of the times, the least injurious opinions harboured of it, are prone to degenerate into irreligion. But I fear, you will think I preach.

The eighth and last OBJECTION.

AND NOW, *Theophilus*, I am arrived at that part of this discourse, wherein it will be fit to examine the grand objection against the style of the scripture, which, though a philosopher would not look upon it as the most considerable, is yet most urged by many of its witty adversaries; especially such as are wont to exercise and gratify their fancy more than their reason: the objection itself is this: ‘That the scripture is so unadorned with flowers of rhetorick, and so destitute of eloquence, that it is flat, and proves commonly inefficacious upon intelligent readers. Infomuch that divers great wits and great persons, especially statesmen, do either despise it, or neglect to study it.’ And truly, the story is famous of that cardinal, (who flourished in the last age) that said, that once indeed he had read the Bible, but if he were to do so again, it would lose him all his Latinity. And amongst those great orators, (as they thought themselves) who lived in the same age and country that he did, the complaint was ordinary, that the reading of the Bible untaught them to the purity of the Roman language, and corrupted their Ciceronian style. And I remember no obscure prince, (though he shall here be nameless, because for other qualities I honour him) in no obscure company, disputed with me one day an opinion about the style of the scripture, to which the cardinal’s scorn was a compliment. I wish these saucy expressions were but outlandish, and could not cross those seas, that environ *England*; (which is not so happily severed from the world’s vices, as from its continent) this profane judging so boldly that book, men shall be judged by, being, if not a native, yet at least a free denizen of *England*. For not only it was one, that I am sorry I can call our countryman, who is recorded to have solemnly preferred one of the odes of *Pindarus*, before all the psalms of *David*; but I could easily add divers resembling instances, that I have myself been troubled to meet with, were it not that I somewhat doubt, whether this kind of profane sayings be not as well fitter as worthier to be forgotten than remembered, and to be suppressed than divulged: for (not to mention, that the recording of such enormities puts an ill compliment upon mankind) the satisfaction some men’s curiosities receive by such relations, will scarce account for the temptation it gives others to imitate what they find some have dared. For there are some sins, whose grand detriment is a kind of persuasion, that they are too horrid to have been committed; and some wise legislators thought it better against certain crimes, to use the silence of the laws, than their threats. I shall therefore, without any further mention of scandalous particularities, take it for granted, that there have been, and are but too many witty disrespecters of the scripture. But as for the accusation it self, which they are alledged to countenance, many defences might be here made against it, if divers considerations pertinent to that purpose, among others, did not belong to some of those ensuing parts of my discourse, wherein it is not the style of the scripture, but other themes, that are principally and directly treated of. Yet that you may be assisted to refer hither such parts of the following discourse, as are applicable to the matter under consideration, I shall here take notice to you, that my answers to the objection above proposed may for the most part be reduced to these five heads of argument.

FIRST,

FIRST, That as to divers parts of the scripture, it was not requisite, that they should be adorned with rhetorical embellishments.

NEXT, That the Bible seems to have much less eloquence than indeed it has, to those that read it only in translations, especially the vulgar Latin version.

THIRDLY, That by reason of the differing notions, several sorts of men, especially of distant nations and climates, have of eloquence; many passages, that are thought uneloquent by us, may appear excellently expressed to another part of mankind.

FOURTHLY, That there are in the scripture a multitude of those texts, wherein the author thought fit to employ the ornaments of language, conspicuously adorned with such as agree even with our notions of eloquence.

AND lastly, That it is very far from being consonant to experience, that the style of the scripture does make it unoperative upon the generality of its readers, if they be not faultily indisposed to receive impressions from it.

As to the first of these, having already above declared, that there are many parts of scripture, wherein it would have been improper to affect eloquence; I am willing to suppose, that you have not yet forgot what has been formerly said; and therefore, I am unwilling to detain you on this first consideration. Yet I cannot but on this occasion take notice to you, that we allow all sorts of people expressions proper and fitted to their several professions and themes. How many of us can dwell on lawyers, physicians, and chymists books; though oftentimes written in terms as harsh and as uncourtly, as if those rudenesses were their design? And yet we can neglect and scorn the scripture, because in some passages we there find the mysteries, and other matters of religion, delivered in a proper and theological style. I remember *Machiavel*, in the dedication of his famous *Prince*, after he had (not causelessly) acknowledged to *Lorenzo de Medici*, (to whom this book is addressed) that he had not stuffed it with lofty language, or big words, nor adorned it with any of those inveigling outward ornaments, usual to other authors in their writings; gives this account of the plainness of his style, [*Perche io ho voluto, o chè veruna cosa la honori (la mia opera) o che solamente la verità della materia, & la gravità del soggetto la faccia grata*] that he thought fit, either that nothing at all should recommend his work, or that only the truth of the discourse and the dignity of the subject should make it acceptable, and exact its welcome. If a mere statesman, writing to a prince, upon a mere civil theme, could reasonably talk thus; with how much more reason may God expect a welcoming entertainment for the least adorned parts of a book, of which the truth is a direct emanation from the essential and supreme Truth, and of which the contents concern no less than man's eternal happiness or misery? And if our nice Italian criticks themselves cannot, by the plainness of *Machiavel's* style, nor the forbidding of his writings by the inquisition, be deterred from as assiduous as prohibited a study of his books; what excuse will they one day have, that now make the unaffected style of scripture the sole excuse of their despising, (or at least neglecting) that divine book?

The second
answer to
the eighth
objection.

SECONDLY, As to the disadvantage the scripture receives by its not being read by those I now reason with, in its originals; though I have said something to it already, yet I must now resume it into consideration, and represent, that it is no wonder they reverence not the Bible's style, as they ought, whilst they judge of that of an Hebrew book by their vulgar translation; which (though sometimes causelessly enough censured by divers protestant divines, that would find it no easy task to make a better, yet) certainly is in many places strangely harsh and barbarous; and by a partial and unlucky affectation of literality, misseeth the propriety both of the Hebrew speech, and of the Latin. And to adhere to the original words commonly injures its eloquence, and oftentimes sense; rendering excellent expressions in such ungraceful ones,

as would probably fright readers from it, if it could not very well spare fine language. So that to our present theme we may not ill apply that notable saying of *Mirandula*; *Hebraei bibunt fontes, Graeci rivos, Latini paludes*. The old French rhiming translation of *Virgil* makes not the *Æneids* much more eloquent than *Hopkins* and *Sternbold* have made the psalms: which sure being written by a person, who (setting aside his inspiration) was both a traveller, a courtier, and a poet, must at least be allowed to contain polished and fashionable expressions in their own language, how coarsely soever they have been mis-rendered in ours. What opinion the eastern world hath of the sweet-finger of *Israel*, may appear, both by other hyperbolical fictions they believe of him, (whom, with *Moses*, *Jesus* and *Mahomet*, they reckon amongst the four great prophets) and by what *Kessæus* (the famed Mahometan writer of the lives of the fathers) relates concerning him; *That when David sang the praises of God, the hills, and birds, and beasts therein accompanied him*. Which gross literal interpretation of figurative expressions in the psalms, and of his pathetic invitations to the inanimate creatures to join with him in celebrating their common Creator, he seems to have borrowed from the Alcoran it self; where *Mahomet* brings God in saying, ‘ We reduced the mountains to comply with him, who should join with him in praises morning and evening; the birds also flock to him; and these are obsequious to him.’ And though the new testament be not written in Hebrew, yet its writers being Hebrews have chiefly conformed themselves to the style of the translators of the old testament, (which whether or no it constitute what criticks of late so dispute of under the name of *Lingua*, or *Dialectus Hellenistica*, I pretend not to define) and that of the apocryphal authors and other Jews writing in the same language; who (except perhaps *Josephus* and *Philo*) wrote rather, if I may so speak, an Hebrew than an Attick Greek; or at least, in a dialect, which (by reason of their frequent references to the septuagint’s version) abounds, if not with Hebraisms, with expressions obvious in Hebrew writings, and unfrequent in Greek ones, and so relishes much of the Hebraick style: of which, as well in the new as the old testament, those we reason with, being strangers to that primitive tongue, must be incompetent judges; there being in the idiotisms of all languages peculiar graces, which (like those most subtil spirits, which exhale in pouring essences out of one vessel into another) are lost in most (especially if literal) translations; and the holy tongue being that, which God himself made choice of to dignify with his expressions, having divers whose penetrancy is as little transfusable into any other as the sun’s dazzling brightness, or the water of a diamond can be undetractingly painted; and having divers words and phrases, whose pithiness and copiousness none in derived (or other) languages can match. Some of the Hebrew conjugations, as those called *Hipbil* and *Hitpaël*, give significations to verbs, which the want of answerable conjugations in western languages makes us unable to fill or equal without paraphrases, which are very rarely so comprehensive as the original words. And (to hint this upon the by) the ignorance, or not considering of this one grammatical truth, hath kept men from fully understanding divers passages of the new testament, wherein the Greek tongue’s want of those conjugations hath made active, or intransitive verbs, be used in a transitive or reciprocal signification. How impertinently men’s ignorance of its originals may make them censure the scripture, I had once occasion to take notice of, by finding a famous commentator accusing St. Paul of impropriety of speech, in the beginning of that, which is commonly thought to be his first epistle to the Thessalonians, but by the learned *Grotius* (in his paradoxes *De Antichristo*) not improbably esteemed to be his second: for whereas instead of the Greek words ἀφ’ ὑμῶν ἐξήχρηται ὁ λόγος τοῦ κυρίου, which ours have rightly Englished, ² *from you sounded out the word*; he found in his translation, *a vobis diffamatus est sermo*; ^{3.}

Kessæus,
page 99.
See Psal.
cxiv. 4.
Psal. xix.

Surat. 3.
Vide H.
Hotting.
62. and 63.

not knowing *Paul* to have written in Greek, he would needs correct him, for having written *Diffamatus est* instead of *Divulgatus est*.

The third
answer.

THIRDLY, we may yet further consider, that as to many passages of scripture, accused of not appearing eloquent to *European* judges, it might be justly represented, that the eastern eloquence differs widely from the western. In those purer climates, where learning, that is here but a denizon, was a native, the most cherished and admired composures of their wits, if judged by western rules of oratory, will be judged destitute of it. Their dark and involved sentences; their figurative and parabolical discourses; their abrupt and maimed way of expressing themselves, which often leaves much place to guesses at the sense; and their neglect of connecting transitions, which often leaves us at a loss for the method and coherency of what they write; are qualities, that our rhetoricians do not more generally dislike, than their practice; yet being perhaps little less disparity in our opinions than in our ways of writing; for their pens (as if it were a preface of the different changes the Jews and Greeks have made in point of religion) move from the right hand towards the left; ours (therein imitated by those of the Ethiopians) from the left towards the right; so that we think they write backwards, and they, that we do. Of this difference of the notions, that the eastern and western colonies of the sons of *Adam* have harboured concerning eloquence, I shall need to mention but one instance, that one is so remarkable; and that is the *Alkoran*. How much the Mahometan world boasts the eloquence of that book, can scarce be unknown to those, that have (though but a little) busied their curiosity in that sort of inquiries. The ablest Arabian expositors, and other authors, tell us, that all the wit and art of men and dæmons would be unable to hinder that book from being matchless. *Mahomet* himself was so proud of it, that in some passages in it he defies its opposers to equal one sura or section of it, and seems to make its peerlessness an argument of its not being barely of human authority. And the Saracens, depressed with their religion's being destitute of attesting miracles, will not scruple to reply, that though there were no other * miracle to manifest the excellency of their religion above that taught by the prophets, yet the *Alkoran* it self were sufficient, as being a lasting miracle that transcends all other miracles. How charming its eloquence may be in its original, I confess my self too unskilful in the Arabick tongue, to be a competent judge; my other studies and distractions having made me forget most of the little knowledge I had once acquired of that flourishing language. But though the *Alkoran* have stolen too much from the Bible, not to contain divers excellent things, (which is one inducement to me to cite it the oftener) yet certainly, not only the ancient Latin version of it, made by order of the abbot *Petrus Guniacensis*, and published in the last age, by the procurement of *Bibliander*, (and of which this is the grand critick *Scaliger's* exclamation, *Deum immortalem, quam inepta est vulgaris illa, quam habemus, interpretatio!*) would scarce by our European orators be thought so much as of kin to eloquent: but the recent translations I have seen of it in French, and (as to divers of it, in) Latin, elaborated by great scholars, and accurate Arabicians, by making it very conformable to its eastern original, have not so rendered it, but that persons, that judge of rhetorick by the rules of it current in these western parts of the world, would, instead of extolling it for the superlative, not allow it the positive degree of eloquence; would think the style as destitute of graces, as the theology of truth; and would possibly as much admire the Saracen admiration, as they do the book. And not only what I have seen of the eminent

Beidavi,
Ahmedibn,
Edris, and
others.

Surat. x.
S. 11. and
S. 17.

J. Scaliger
Epist. 362.
apud Theod.
Hackspan in
libro cui
titulus,
Fides &
Leges Mo-
hamedis.
page 2.

* ——— *Esti nihil præter solum Alkoranum (adduxisset) satis hoc foret ad eximiam excellentiam supra reliqua, quæ prophætæ adduxerunt: nam ille miraculum est, quod in secula durat præ omnibus aliis miraculis.*
H. Hotting. Hist. Orient. pagina circiter 300.

East-Indians, is strangely incongruous to our notions of eloquence; but what I have perused of the famous *Literati* (as they call the learned men) of *China*, though written with great care by the authors, and (as it seems) translated with no less by the knowing interpreters, would, to an ordinary European orator, appear rather ridiculous than eloquent. But to content ourselves with the examples we formerly selected out of the less remote parts of the East; since *Mahomet*, whose eloquence (almost as prosperous as his sword) was able to bring credit and proselytes even to such a religion as his; since *Moses*, that so celebrated legislator, bred up in the refining court, and all the famed wisdom of the Egyptians; since *Solomon*, who had such incommunicable advantages to improve himself, and whose wisdom (esteemed capable to have governed more kingdoms than his had subjects) the western world hath for so many ages admired, and the eastern only not idolized; and since the prophet *Daniel*, whose promising youth was not only cultivated by the instructions of the Chaldean sages, but enjoyed the diviner tutorage of God's spirit, and whose matchless abilities preferred him, from a captive, to be the chief as well of the Chaldean wise men, as the Median princes: since these applauded writers, I say, whom the eastern nations so much and so justly admired, by many of our Latinists are not thought good writers, because of our differing notions of eloquence; nay, if amongst Europeans themselves, *Cicero* hath found many censurers, and a book hath been published to prove, that *Tully* was not eloquent; may not we rationally enough suppose, that the Grecian and Roman style, amongst the eastern writers, may not be much better relished than theirs is amongst us; and that consequently, in those parts of the scripture, whose eloquence is not obvious to us Europeans, the pretended want of eloquence may be but a differing and eastern kind of it? Specially, if we consider, that the ancientest writers in prose, now extant amongst us, were scarce cotemporary to the latest writers of the old testament; and yet that eloquence, the dress of our thoughts, like the dress of our bodies, differs not only in several regions, but in several ages. And oftentimes in that, as in attire, what was lately fashionable, is now ridiculous; and what now makes a man look like a courtier, may within these few lustres make him look like an antick: though how purely it is the mode, that makes such things appear handsome or deformed, may be readily collected from the vicissitudes observable in modes; men by intervals relapsing into obsolete fashions. That there are great changes in that mode of writing men commonly mistake for eloquence, I shall produce no less illustrious a witness than *Seneca*, who in his hundred and fourteenth epistle, (to omit other passages in his works) not only proves it at large, but shows, that in some ages, even the faulty ways of expression, conspired in by the wits of those times, have passed for eloquence. The scripture style then, though it were not eloquent now, may have excellently suited the genius of those times its several books were written in; and have been very proper for those people it was primarily designed to work upon. And if I would presume to be paradoxical in a thing I so little pretend skill in, as eloquence, I might further represent on this occasion, that rhetorick being but an organical or instrumental art, in order chiefly to persuasion, or delight, its rules ought to be estimated by their tendency, and commensurateness to its rules; and consequently, are to be conformed to by a wise-man, but so far forth as he judgeth them seasonable and proper to please or to persuade: which when he sees, he can do better by declining them, than by practising them, (as orators, like hunters, must oftentimes leave the most beaten paths, if they will not lose their game) he should not scruple to prefer the end to the means; the scope of the artist, to what the schools are pleased to call the scope of the art; and to think it more eligible to speak powerfully, than to speak regularly. And we may hence consider, that it may be somewhat inconsiderate to

A short digression concerning the art of rhetorick.

judge of all eloquence, by the rules of it, that *Cicero's* admirers impose on us; and confound their systems of precepts with the art of rhetorick, as if they were equivalent, or of the same extent. For *Cicero* being reputed (and that deservedly) an eloquent man, and very successful in persuading his thus and thus qualified hearers; divers, whose modesty and despair kept them from aspiring to more than imitation, observing, that *Tully* often made use of such and such a contrivance, and such and such figurative forms of speaking, took the pains to reduce those observations into rules, which being highly applauded by their successors, and by them recruited with some resembling rules drawn from the practice of a few other orators, were afterwards compiled into an art, which as I deny not to be a great help to the imitation of *Tully* and *Demosthenes*, or those others, from whose structure and fashions of speech such institutions have been drawn, so I shall no more take it for a complete system of rhetorick, than any instructions deducible from the journals of *Solomon's* Taffish fleets, and from the Grecian and Roman sea-voyages, for the true and entire art of navigation. For if other persons, either by an endowment or improvement of nature, can find others equally, or more happy and powerful, or moving, (though never so differing) ways of expressing themselves, they ought as little to be confined by the prescriptions acquiesced in before them, as *Columbus* thought himself obliged to be by the rules or practice of ancient navigators; whose methods and voyages had he not boldly ventured to vary from, and pass beyond, how vast and rich a portion of the world had his conformity left undiscovered! And on this occasion, *Theophilus*, I must mention one thing, that I have observed, which perhaps you will not think either despicable or impertinent; and it is, that though the people of *China* be esteemed the most numerous, the most flourishing, and (very few, if any, excepted) the most civilized nation in the world; though amongst them the greatest part of preferments be attainable by verbal learning; and though they have books in their language (how well written, I know not, having never read any of them) of almost all kind of liberal arts and sciences; yet I find by the late traveller in *China*, that writ the Italian history of that kingdom, and by other authors, that mention their literature, that this populous and ingenious nation, that has been so long settled in a flourishing condition, and more than any other people allows encouragements and recompences to learned men, has not cared to receive rhetorick into the number of their arts and sciences; presuming, as one may guess, that the confining men's expressions to established rules would not be so like to enable those to express themselves eloquently, that nature has indisposed to do so, as to hinder others from expressing themselves as well, as, were they left to their full liberty, they would do. I will not say, nevertheless, that our strict Ciceronian rules are crutches, that may be helps to weak or lame fancies, but are clogs or burdens to sound and active ones; but this I observe, that these Utopian laws of oratory are seldom rigorously imposed by any, that publish other books, that may be examined by them; and that wisemen, as well in the West, as in the East, will not easily lose good thoughts, or good expressions, because they are not reducible to them. And this I the rather press, because I have found but too many so blindly servile, as to imitate without discretion or reserve in applauded authors, as well the bad as the good; create such artists errors rules of art; and make one man's particular fancies, or perhaps failings, confining laws to others; and convey them as such to their successors, who are afterwards bold to mis-name all unobsequiousness to their incogitancy, presumption: as *Seneca* * tells us of divers im-

* — *Hæc vitia unus aliquis inducit, sub quo tunc eloquentia est: cæteri imitantur, & alter alteri tradunt. Sic Sallustio vigente, amputatæ sententiæ & verba ante expectatum cadentia, & obscura brevitæ, fuere pro cultu.* Seneca epist. 14.

perfections of style, which being familiar to some one, who at that time hath the vogue for eloquence, are upon his score copied by his imitators, and by them taught to others: as, (says he) when *Sallust* flourished, his style made maimed and abrupt sentences, words surprisngly mis-placed, and an obscure brevity pass for ornaments. And indeed, it is not uneasy for any man to observe the very weeds of cried up rhetoricians cried up for flowers of rhetorick. But having already wandered, perhaps, too far in this digression, I shall now conclude it; and though, since it is for the scripture, and with its enemies that I am contending, I shall venture to do it, with minding our cardinal, and those that so undervalue the scripture's ways of expression, in comparison of *Tully's*, because his books do so regularly express the rules of eloquence; that it is no marvel they should find *Cicero's* writings to be so conformable to their laws of art, whilst they frame those laws of art out of his writings.

BUT, *Theophilus*, I fear I have detained you too long in a digression, whereinto I slipt but occasionally, which is not so necessary to my present argument, but that I am content you should look upon the paradox as any thing rather than an opinion or reasoning, whereon I lay any great stress.

IN the fourth place then let me represent to you, that there are very few, if any books in the world, that are no more voluminous, in which there is greater plenty of figurative expressions, than in the Bible. Though this may seem strange, it is no more than may be made good by more than some hundreds of instances; there being few tropes or figures in rhetorick, of which numerous examples are not collectible out of the expressions of holy writ. I insist not upon this, because a bare catalogue of the rhetorical passages, I could enumerate, would too much swell an essay; and I am informed, that task hath been already prosperously undertaken by abler pens. Wherefore I shall now only say, that the eloquence of the scripture hath been highly celebrated by no small number of persons, highly celebrated for eloquence; and that many, who thought themselves as intelligent in oratory, as those that censure the scripture, have suspected their own eloquence of insufficiency worthily to extol that of the prophet *Ezay*; and some of them, (amongst whom I cannot but name that excellent prince of *Mirandula*, whom even the greatest rabbi of this age styles the phoenix of his age) who after having unsatisfiedly travelled thorough all sorts of human volumes, have rested and acquiesced only in these divine ones: which will not a little recommend the scripture, since we may apply to books what an excellent poet says of mistresses;

The fourth
answer to
the eighth
objection.

Menasse
Ben-Israel.

'Tis not that which first we love,
But what dying we approve,

Mr. Waller,

that we express the highest value of. And indeed, the best artists making two parts of oratory; the one, which consists in the embellishments of our conceptions, and the other, that consists in the congruity of them to our design and method, and the suitable accommodation of them to the various circumstances considerable in the matter, the speaker, and the hearers; this latter is peculiarly and inimitably practised in the scripture; and as much of the former (which is not only less considerable, but is changeable and unagreed of) as we have newly seen, is made use of, as is requisite to the author's purposes, and to manifest, that delicacy or smoothness never ceases to be the property of his style, but because in some cases it would be incongruous to his design. And where these verbal ornaments are spared, they are not missed; for as there are some bodies so well shaped and fashioned, that any clothes become them much better than the most fine and graceful would do ordinary (much more

more crooked or mis-shapen) persons; so there are writings, whose matter and structure are such, that the plainest language can scarce mis-become them so, as to hinder them from eclipsing a trifling or ill-matched subject with the sprucest and gaudiest expressions, that can be lavished on it. But the truth is, that this florid eloquence is great in many texts, where it is not all conspicuous, being hidden in the matter; (as in roses of diamonds, the jewels oftentimes keep us from minding the flower and the enamel;) and appears not great, but because it is not the greatest. Some famous writers have challenged *Demosthenes* and *Cicero* to compare with the prophet *Esay*; in whom they have not only admired that lofty strain, which artists have termed the sublime character, but even that harmonious disposition and sound of words, (I mean in their original) which the French prettily call, *la cadence des periodes*.

WHEREFORE, *Theophilus*, whereas I have formerly acknowledged, that there are some witty men, that speak very disrespectfully of the scripture, I hope, that if you meet with any such, you will consider, that it has among the wits as well celebrators, and admirers, as disregarders. And that you may think this desire of mine the more reasonable, be pleased to consider with me, that there are divers things, which ought to lessen the authority of the disparagers of the scripture, in the case under consideration.

FOR first, how few of them, think you, are wont to read it in its originals; and how much a less number is there of those, who both know and duly consider all those particulars represented in the past discourse on the behalf of the scripture style? So that in a great many men of parts, their undervaluation of the scripture proceeds not from their having great wits, but from their not having a competent information of what can be alledged for its justification.

BUT though we should suppose those we speak of not to want information, yet we may well suppose many of them not to be free from vanity and envy; there scarce being any fault so incident to great wits, as the ambition of being thought still more and more so, and the unwillingness, that any composures but their own, or those they have a hand in, should be celebrated; as if all praises were injurious to them, that are given to any other. It need be no great wonder then, if so excellent a book as the scripture, have as well enviers, as admirers; and if there be divers, who cavil at it, and seem to undervalue it, out of a criminal fondness of the over-ambitioned title of a wit, which they hope to acquire by unherding and keeping out of the road, and owning their being able to slight and disgrace that, which so many others reverence and venerate.

BUT thirdly, it is sufficiently notorious, that of the opposers of the scripture there is a great part, whose vanity and envy, though no small faults, are not their greatest crimes; but who live so dissolutely and scandalously, that the suspicion cannot but be obvious, that such decry the scripture for fear of being obliged (at least for meer shame) to live more conformably to it. And that it were no slander to affirm it to be their interest, not their reason, that makes them find fault with a book, that finds so much fault with them; and they who are sensible of the truth of that of our Saviour, where he says, *That many love darkness rather than light, because their deeds are evil*; and that *he that doth evil, hateth the light, neither cometh to the light, lest his deeds should be reproved*; will not be much moved to find conscious malefactors find fault with the statute-book, but will rather look upon these sinners censures of the scripture, as apologies they judge necessary to palliate their sins, or as acts of revenge, for their being exposed in all their deformity to the eyes of the world, and of their own consciences, in the Bible; and consequently will be inclined to think, that their
irreligious

irreligious expressions do rather shew what they would have men believe of them, than what they believe of the scripture, by seeming to slight which, they hope to have their vices imputed rather to a superiority of their reason over that of others, than a servitude of their reason to their passions

[HERE I thought to pass on to another argument, but (to express my self in David's words) *While I was musing, the fire burned*, and my zeal for the scripture, together with the charity it has taught me to exercise even towards its opposers, suffers me not, with either silence or languid resentments, to see how much that incomparable book loses of the opinion of less discerning men, upon the account of their disrespect, who are (whether deservedly or not) looked upon as wits. And therefore to what I have represented to invalidate the authority of these few persons, otherwise truly witty, that undervalue the scripture, I am obliged to add, that besides them, there is a number of those, that slight the scripture, who are but looked upon as wits, without being such indeed; nay, who, many of them, would not be so much as mistaken for such, but for the boldness they take to own slighting of the scripture, and to abuse the words of it to irreligious senses, and perhaps passing from the impudence of perverting inspired expressions, to deliver obscene thoughts. But to knowing and serious men, this prevaricating with the scripture will neither discredit it, nor much recommend the prophane prevaricator: for a book's being capable of being so mis-used is too unavoidable to be a disparagement to it. Nor will any intelligent reader undervalue the charming poems of *Virgil* or of *Ovid*, because, by shuffling and disguising the expressions, some French writers have of late been pleased out of rare pieces to compose whole books of what they call, *Vers Burlesques*, designed by their ridiculousness to make their readers sport: and on the other side, to abuse dismembred words and passages of any author to meanings he never dreamed of, is a thing so easy, that almost any man may have the wit to talk at that prophane rate, that will but allow himself the sauciness to do so. And indeed experience shews, that if this vice itself do not make its practices suspected of the being necessitous of the quality they put it on to be thought masters of, yet at least persons intelligent and pious will not be apt to value any discourse as truly witty, that cannot please the fancy without offending the conscience, and will never admire his plenty, that cannot make an entertainment, without furnishing out the table with unclean meats; and considering persons will scarce think it a demonstration of a man's being a wit, that he will venture to be damned to be thought one. And that which aggravates these mens prophaneness, and leaves them excusable in it, is, that there are few of these *fools*, (for so the wise-man calls them) that *make a mock of sin*; that have said in their hearts, *that there is no God*; or that the scripture is not his word; their disrespect to the scripture springing from their vanity, not their incredulity. They affect singularity, for want of any thing else that is singular; and finding in themselves strong desires of conspicuousness, with small abilities to attain it, they are resolved with *Erostratus*, that fired *Diana's temple*, to be talked of for having done so, to acquire that considerableness by their sacrilege, which they must despair of from their parts. And indeed there want not many, who have so little wit, as to cry up all this sort of people for great wits. And as withies, whilst they are sound, grow unregarded trees, but when they once are rotten, shine in the night; so many of these pretenders, whilst they were not very prophane, were (and that justly) esteemed very dull; but now that their parts are absolutely corrupted and perverted, they grow conspicuous, only because they are grown depraved. And I shall make bold to continue the comparison a little further, and observe, that as this

A long digression against prophaneness, as it relates to the scripture. Pf. xxxix. 3.

Pf. xiv. 1.

Pf. lxxiii.
8, 9.

rotten wood shines but in the night; so many of these pretenders pass for wits but amongst them, that are not truly so. For persons really knowing can easily distinguish betwixt that, which exacts the title of wit from our judgments, and that which but appears such to our corruptions. And how often the discourse we censure is of the latter sort, they need not be informed, that have observed, how many will talk very acceptably in derogation of religion, whom, upon other subjects, their partiallest friends acknowledge very dull; and who are taken notice of for persons that seldom say any thing well, but what it is ill to say. And questionless, there is no small number of these scorers, whose censures of the scripture's style are little less guilty of presumption than profaneness. I have of late years met with divers such vain pretenders, who blush not to talk of rhetorick more magisterially than *Aristotle* or *Tully* would; and superciliously to deride, in comparison of their own writings, and theirs who write like them, not the Bible only, but the most venerated authors of antiquity; and, to use *Asaph's* words; *They speak loftily, they set their mouth against the heavens, and their tongue walketh thorough the earth*: they speak arrogantly and censoriously both of God and men; whilst themselves oftentimes understand no tongue but their mothers; and are strangers enough to rhetorick, not to know the difference betwixt a trope and a figure, betwixt a prosopopœia and a metaphor, or betwixt a climax and a metonymy. Nor is our wonder like to cease, to find these transcendent wits, (as they are pleased to think themselves) so undervalue the scripture, by considering the rare composures they despise it for; these being commonly no other than some drunken song or paltry epigram, some fawning love-letter, or some such other flashy trifle, that doth much more argue a depressed soul, than an elevated fancy. Some of these gallants by their tavern songs use the muses like anchovies, only to entice men to drink: another with more solemnity and applause makes the muses (what the French call) the confidants of his amours, prostitutes his wit to evince and celebrate the defeat of his reason, and never considering how apt self-love makes us to magnify any thing that magnifies us, is proud to have wit ascribed him by as bribed as incompetent judges of it; and takes it for as high a proof as desirable a fruit of eloquence, to persuade a vain mistress, that she is handsome and adored, to whom it were eloquence indeed to be able to persuade the contrary. Divers of the Jews are wont to mention the names of deceased sinners, with that brand taken out of the *Proverbs*, *May the name of the wicked rot*; but as the filthiest swine after their death are salted, and the gammons made of their flesh are served in, all stuck with bays; so divers, that have lived notorious Epicures, have too often, after their death, not only their names salted (not to say embalmed) with flattering epitaphs, and (I wish, seldomer, as flattering) funeral sermons; but have their drunken or lustful rhimes extolled with such eulogies by their surviving ressemblers, that not only good Christians, but good poets cannot but grieve and blush, thus to see bays, that should be appropriated to, and crown that heavenly gift called poetry, when mindful of its dignity and extraction, it dears to us by our fancies truths, that should have an influence on our affections, (by cloathing excellent thoughts in suitable and winning dresses) prostituted and degraded to make wreaths for those, who have no better title to them, than a few sensual rhimes, where the dictates of *Horace* are as little conformed to, as the example of *David*; and the laws of the art little less violated than those of religion. It is pleasant to observe, in how many of such copies of verses, the themes appear to have been made to the conceits, not the conceits for the themes; how often the words are not so properly the clothes of the matter, as the matter the stuffing of the words; how frequently sublime nonsense passes for sublime wit; and (though, according to my notion of it, that is indeed

indeed true wit, which it is more easy to understand, than it is not to admire it) how commonly confused notions, and abortive or unliked conceptions, are in exotick language, or ambiguous expressions, exposed to the uncertain adoption of the courteous reader; which the writers are emboldened to expect favourable, by finding men once thought (whether deservedly or otherwise) lofty wits, to have so often the luck of parrots, and of those that talk in their sleep, who are not seldom understood by others, when they do not understand themselves. And very much of kin to their verses is their prose. For though I am far from denying, that those, that have store of wit, may express some of it in an address to a great man, or in writing to a mistress; yet as for such prophane persons I am now speaking of, who rather would be thought wits, than are so, it is easy to discern, that very many of their almost as much flattered as flattering letters of love and compliment are but prologues to, and paraphrases of the subscription, (your humble servant.) Though love be universally thought to make the fancy soar, (lovers like ceeled pigeons flying the higher for having been blinded) and though even the wiser observe, that like war, which is wont as well to raise soldiers of fortune, as to ruin men of fortune, love warms and elevates lesser wits, though it too often infatuate the great ones: yet a witty lady did not scruple to say frequently, that give her but leave to bar half a score words, and she would undertake to spoil all the fine letters of our amorous gallants. I applaud not the severity of this lady, and think her challenge relishes as much of vanity as skill; but yet, to express the sense of these few words, [I desire you should think I can write well, am a civil person, and your humble servant] being the drift and substance of most of these ceremonial papers; these (oftentimes as tedious as servile) amplifiers, with all their empty multiplicity of fine words, do but, like market-people, pay a piece in twenty shillings. In wits not blessed with solid reason and learning, (that is, in most readers) fancy being the predominant faculty, makes them relish those writings most, where fancy unrivalled reigns. And therefore, though I dare not say, that it requires no great parts for those to write high and acceptable compliments, that think nothing fit to be endeavoured in compliments, but to make them acceptable by making them high enough; (flattery and prophaneness seeming in such composures what spots are in leopards, blemishes, that make a great part of their beauty) or for a flatterer to persuade those vain persons, that will readily believe a man, even when he doth not believe himself: yet sure it gives much latitude and liberty to a writer, not to be obliged to believe what he says, not say but what he thinks either will be or ought to be believed. And truly, they that exercise their pens on either sort of themes (I mean those that require only new or pleasing fancies, and smooth language, and those that require learning and knowledge pertinently and handsomely expressed) do, I doubt not, find it much less difficult for writers to delight, where they propose themselves no higher end, and scruple at nothing they judge conducive to that inferior one; than to please, where to do so is but a subordinate end, which men allow not themselves, neither the use of all proper means to attain. Nor do I question but such persons find it far more easy to write acceptably on subjects, where they are not tied to speak either reason or truth; than to write well on a theme, where men are confined to write nothing but what they judge useful, and what they can make good, as considering that they may be called to account by men for what they publish, if not by God, both for their own time and that of their readers. And indeed, when I compare the most applauded trifles of these undervaluers of the scripture style, with the celebrating discourses of it extant in the learned writings of *St. Austin*, *St. Hierom*, *Tertullian*, *Lactantius*, *Chrysostom*, *Mirandula*, and others, whose penetrant and powerful arguments defeat not God's enemies, as *Samson* did the

Judg. xv.
15.
Judg. iii.
31.
2 Kings i.
10.
Rev. xxi.
10, 18, 19.

Philistines, *with a jaw-bone of an ass*, nor as *Shamgar with an ox-goad*, (I mean with blunt and despicable weapons) but as *Elias did, with fire from heaven*; and whose apologetical defences of the spiritual *Jerusalem* are glittering and solid, as the wall of the heavenly *Hierusalem* is described to be of jasper, *and the foundations of the wall garnished with all manner of precious stones*: when I compare, I say, the composures of our frothy censurers, with those of the sacred orators; methinks I discern such a difference betwixt them, as I have observed betwixt those justly admired statues I have seen in the Capitol, and the larger sort of babies that we find in the exchange. For the former, besides their vastness, are so recommended by the worth and permanency of their matter, the excellency of their workmanship, and the nobleness of what they represent, that they are most prized by the best artists, and time is not only unable to consume them, but still increases mens value of them; whereas the latter are little trifles, scarce welcome to any but children in understanding, and admired only for a gaudy effeminate dress, which will quickly either be sullied or worn out; and a fashionableness which within a short while will perhaps be ridiculous. But supposing at length, that the profane aspirer should be so lucky, or so successful, (for happy I cannot think it) as to attain the so criminally courted notedness, yet will he have no great cause to boast the purchase, when he seriously considers, that the devil, who seduces other sinners like men, with current coin or sparkling jewels, (something that either advantages their interests, or delights their senses;) hath enveigled him, like a child, with a whistle; a trifle that only pleases with a transient and empty sound; and, that fame is a blessing only in relation to the qualities, and the persons that give it, since otherwise the tormented prince of devils himself were as happy as he is miserable; and famousness unattended with endearing causes is a quality so undesirable, that even infamy and folly can confer it; as *Momus* is little less talked of than *Homer*; the unjust *Pilate* is more famous than *Aristides* the just; and *Barabbas* his name is signally recorded in scripture, whereas the penitent thief is left unmentioned. And sure the highest favours, that applause can impart, and the being (though never so loudly) cried up for a wit, will hardly so repair the punishment of prophaneness, but that its wretched sufferer will find but small satisfaction in having his name celebrated in other books, whilst it is blotted out of that of life. And as for those (you know who I mean) that aspiring to postume glory, endeavour to acquire it by irreligious writings destinated not to see the light, till their authors be gone to the region of darkness; I cannot but admire to see an ambition, that projects beyond the grave, step short of heaven; and cannot but think those wits the greatest fools, who, to tempt praises they shall never hear, provide themselves torments that they shall ever feel. For though prophaneness, by those that are guilty of it, be too often thought but a small sin, because they look upon it but as a verbal one; yet I could easily represent it under another notion, if I would here repeat what I have discoursed, touching indulgence to reputedly small and verbal sin in another paper, from which though I will not now transcribe any thing, yet I cannot but wish it were well considered, how affronting speeches concerning God's word are like to be looked upon in that great day, when (to borrow St. Jude's terms) *the Lord shall come with ten thousands of his saints, to execute judgment upon all, and to convince all that are ungodly among them, (not only) of all their ungodly deeds, which they have ungodly committed, (but) also of all their hard speeches, which ungodly sinners have spoken against him.* And indeed these presumed peccadillos, though oftentimes in health and prosperity they appear not to us to blemish much our consciences, yet when in our distresses, or at the approaches of death, God comes, as the prophet speaks, *to search men's hearts as it were with candles, and punish the men that are settled upon their lees,* (which

Jude ver.
14, 15.

Zeph. i.
12.

(which whilst a liquor is, it may look clear, and be taken for defecated, but a little agitation of the vessel strait makes it troubled and muddy;) they appear in a terrifying form. For as paper written upon with juice of lemons may wear white (the livery of innocence) whilst it is kept from the fire; but being held to it, black lines do presently appear: so out of many consciences, that seem clear in prosperity, the fire of adversity draws out the latent blacknesses, and makes us read things undiscerned there before. And questionless, if, as the scripture informs us, *there are sins, whose cry is able to reach heaven*; so loud a crime as the prophaneness I am now speaking of, is likely to do more than whisper there; especially, since it is much to be feared, that many of these scoffers (as they seem to be called in the scripture) which they bear witness to, by cavilling at it, do *rebel against the light*, and *kick against the pricks* of their own consciences: such a crime, I say, will be so far from whispering in heaven, that it will rather give an alarm, that will rouse up provoked justice; whose inflictions, like stones tumbled down from the towers of an assaulted place, the longer they are in falling on men, the more fatally they oppress them. In which regard perhaps, the feet of our Saviour in the Apocalypse are described to be like unto fine brass, as if they burned or glowed in a furnace; to intimate, that though he be very slow in his march to destroy the wicked, yet he is as sure, when once he pleases to tread them under foot, to crush and consume them. If there be no injury, that more exasperates than contempt, nor no contempt, that more provokes than that, which offends directly and immediately, (the affronters thereby proclaiming, that they are neither ashamed nor afraid of angering) how provoking may we think that crime, which makes God the subject of our derision; and that with so little circuition, as to abuse that word, which he so solemnly declared his mind by to mankind? *Plutarch*, to manifest how much some idolaters did more incense the Deity than some artists, tells us, he should esteem himself less injured by the man, that should doubt or deny, that there was ever any such man as *Plutarch*, than by him, that should affirm, that there was such a one indeed, but that he was an old fellow, that used, like the poet *Saturn*, to devour his children; and was guilty of those other crimes imputed by the Heathen to their gods. Upon a like account, we may esteem God less provoked by their unbelief, that doubt or reject the scripture, than by their prophaneness, that make so sacrilegiously bold with it; since the latter impute to God the inditing of what they endeavour to make men think fit to have sport made with it. This of prophaneness is so empty and unprofitable a sin, that it scarce gets the practiser any thing but an ill name amongst good men upon earth, and a worse place amongst bad men in hell; by making his enmity to piety so malicious and so disinterested, that he will endeavour to do religion harm, though it be to do himself no good. He is such a volunteer sinner, that he hath neither the wit nor the excuse of declining his conscience in compliment to his senses; and though he ever makes but an ill bargain, that gets in hell to boot, yet those I would reclaim, come far short of the comparative wisdom of their folly, who to gain so considerable (though yet over-purchased) a possession as the whole world, should part with their own souls. And sure a sin, that is injurious to God's glory, and is apt to subvert (what he and good men prize next) the dearly purchased, immortal, and invaluable souls of men, and to *destroy them for whom Christ died*; will not by being verbal, be protected from being heinous. And to those that practise it, I shall recommend the latter half of the epistle of *Jude*; which, though it seem properly to relate to the Gnosticks, or Carpocratians of his time, will deserve a trembling attention from those that revive the sins there condemned, in ours; and who would do well, by seasonably considering the fate there threatened to their predecessors, to tremble at their crime.

Gen. xviii.

21.

2 Pet. iii. 3.

Jude ver.

17, 18.

Rev. i. 15.

Rom. xiv.

15.

1 Kings xii.
28, 32.Proverbs
xxvi. 5.Exod. xxiii.
3, 4, 5, &c.

Dan. xii. 4.

Hos. ii. 8.

1 Chron.
xxix.

Jer. i4.

1 Cor. iv. 7.

But for fear of losing it, I shall not spend more time in endeavouring to disabuse our scornors; whom I should have left to the quiet enjoyment of their unenvied self-admiration, had not their despising the scripture, upon a presumption of their own matchless wit, (like *Jeroboam*, that forsook that incomparable structure, the temple, where God did so gloriously and peculiarly manifest himself to men, to worship calves of his own making) engaged me, in conformity to the wise man's counsel in such cases, to *answer the fool according to his folly, lest he be wise in his own conceit*. For my reproofs are addressed to those called wits, but as they are traducers and undervaluers of the scripture, not as they either pretend to, or enjoy, a quality, which I have the justice to esteem, though not the happiness to possess; and which my value for it, and my charity for men, makes me troubled to see arrogated by many that want it, and by too many, that have prostituted it to gratify other people's pride, or their own lusts. How* much happier were it for persons of choice parts to employ them, as *Bezaleel* and *Aboliab* did theirs, in working for the sanctuary; in asserting the embellishing divinity? The structure will not alone deserve the skillfullest hand, but though it reject not goat's hair, and coloured badger's skins, will admit not only purple and fine twined linen, but gold, silver and precious stones; the richest ornaments, that learning and eloquence can grace theology with, being not only merited by that heavenly subject, but being applicable to it, as much to their own advantage as to that of their theme. We see how ambitious men are, to leave a good name behind them, and appear in the habit of virtue to their own after time: witness the artifices and hypocrisy men generally veil or disguise their sins with; and the flattering epitaphs, with which so many vicious persons endeavour to convey themselves to the good opinion of posterity. Now they that write piously, as well as handsomely, have the advantage of getting themselves the reputation as well of virtuous as of able men, and besides that double recompence may expect a third (transcending both) in heaven, where they that (in the true scripture sense) *be wise, shall shine as the brightness of the firmament, and they that turn many to righteousness, as the stars for ever and ever*. It is the general complaint and grief of persons truly zealous, that there are many more wits and grandees now-a-days, who, by perverting God's gifts to the service of idols (of pride or pleasure) of their own setting up, resemble the degenerate Jewish church, of whom God complains by *Hosea*, that *she did not know, that he gave her the corn and wine and oil, and multiplied her silver and her gold, which they prepared for Baal*; than that (by an humble dedication of their choicest abilities to God's service) imitate holy *David* and his princes; who having consecrated their gold and silver and precious stones, towards the enriching and embellishing of the temple, perfumed that vast offering with this acknowledgment to God; *All things come of thee, and thine own have we given thee*. But though now I know divers great persons and great wits amongst us, who very unmindful of that text, *What hast thou that thou didst not receive*, like those ungrateful clouds that obscure the sun that raised them, oppose the glory of that God, who elevated them to that height: yet I do not absolutely despair, that as God hath been pleased to make use of several royal pens for the tracing of his word, and to make a person, learned in all the wisdom of the Egyptians, his first secretary; so he will one day engage both the grandees and the wits to strive to expiate, by their devotion and service to the scripture, the injuries, that irreligious parts and greatness have done it. I will not tell you, *Theophilus*, that an early study of religion would gain to its party most of those many wits, that will be sure to con-

* An appendix to the former digression, inviting one sort of witty men to make amends for the prophaneness of another.

tend for whatever opinion is expressed by the wittiest things they can say. But I will tell you, that a particular consideration, that makes me wish to see witty writers more generally employ their pens on the behalf of religion, is, that the services they do it, endear it to them: for as *Machiavel* smartly observes, and as the love of parents and nurses to children may evince, *La natura de gli huomini è così obligasi per li beneficii che esse fanno, come per quelli che essi ricevono.* It is natural to men, to be as well engaged by the kindnesses they do, as by those they receive. And for the encouragement of the possessors of great parts, to employ them on religious themes, such as the holy scripture; I shall represent to them, that even that immortality of name, which worldly writers (for the most part) solely aim at, is not by pious writers less found for being last sought: their theme contracts not their fame by a true diminution, but only by comparison to a greater good: their looking upon their own glory but as an accession to God's, not hindering others from praising that wit and eloquence they praise God with; as beauty made it self admirers, though in vestals, and a rare voice may ravish us with a psalm; or as the jewels that adorned it, shone with their wonted lustre on *Aaron's* breast-plate; yes, as *godliness is profitable unto all things, having promise of the life that now is, and of that which is to come; and the hundred fold now in this time,* is very consistent with the eternal life in the world to come: so is it very possible for the same pious writer to have his name written at once in both those immortal books of life and fame; and (like the inspired poet, holy *David*) wear as well here a crown of laurel, as hereafter, τὴν ἀμάραντον τῆς δόξης στέφανον, that unfading crown of glory *St. Peter* speaks of. And though we are too generally now-a-days so sinful, that we scarce relish any composure, that endeavours to reclaim us from being so; yet less licentious and more discerning times, (which may be, perhaps, approaching) will repair the omissions and fastidiousness of the present, by an eminent gratitude to the names of those, that have laboured to transmit to others, in the handsomest dress they durst give them, the truths themselves most valued. And I observe, that though *Solomon* himself delivered so many thousand songs and proverbs, and the nature of beasts, birds, reptiles, and fishes, together with the history of plants from the cedar of Lebanon, even to the hyssop that springeth out of the wall; yet those three only treatises, designed peculiarly for the instruction of the church, survive their lost companions. And as anciently the manna, which the Israelites gathered to employ in their domestic uses, lasted not unputrified above a day or two; but that, which they laid up in the sanctuary to perpetuate or secure God's glory, continued whole ages uncorrupted: so the books written to serve our private turns of interest or fame are oftentimes short-lived; when those, consecrated to God's honour, are, for that end's sake, vouchsafed a lastingness and kept from perishing. And those many dull and uneloquent glosses and expositions of the ancient Jews, that the merit of their theme hath preserved for so many ages, may assure us, that the scripture doth often make their names and writings that illustrate it, partakers of its own prerogative of immortality. Not to mention that (according to that of the Psalmist, *I have more understanding than all my teachers; because, יְיָ, thy testimonies are my meditation*) such an employment of parts doth oftentimes invite God to increase them; as he that had most talents committed to him, for improving them to his Lord's service, was trusted with more of them; and he, who employed some few cups of his wine to entertain our Saviour, had whole vessels of his water turned into better wine. Certainly, transcendent wits, when once they addict themselves to theological composures, improve and grace most excellently themes so capable of being so improved. They need small time to signalize their pens; for possessing already in a sublime degree all the requisites and appropriates of rare writers, they need but apply that choice knowledge and charming eloquence to divine subjects to handle them to admiration;

Nicholo Machiavelli nel libro del Principe, c. 10.

1 Tim. iv. 8.

Mark x. 30.

1 Pet. v. 4.

1 King iv. 31, 32, 33.

Exod. xvi. ver. 20, 33, 34.

Psal. cxix. 99.

Mat. xxv. 28. John ii. to the tenth verse inclusively.

1 Kings vii.
13, 14, &c.

Judge. xl.

Numb. xvi.
4, 8.

Deut. xxi.
18, 19.

Ver. 20.

1 Sam. ii.
20, 21.

Ver. 18.

Rambam, or
Rabbi Moses
Ben-Maimon.

Job. i. 8.

as *Hiram* successfully used the skill he had learned in *Tyre*, in the building and adorning of God's temple; and *Jephtha* victoriously employed the military gallantry and art, that had made him considerable in the land of *Tob*, in defending the cause, and defeating the enemies of God. Of this truth the primitive times afford us numerous and noble instances; but especially that stupendous wit *St. Austin*, (whom I dare oppose to any of the wits, that have dared to oppose the scripture) the productions of whose wit in his unregenerate state, and after his conversion to the catholic faith and piety, oblige me to resemble him to *Aaron's rod*; which (supposing the truth of their opinion, that think it to be the same that *Moses* used) whilst it was employed abroad, did indeed for a while work wonders, that made it much admired; but when once it came to be laid up in the tabernacle, unconfined to the usual laws of other plants, it shot forth and afforded permanent fruit in a night. But, *Theophilus*, to recover my self at length from my over-prolix digression, I must remember, that it was objected, that as well divers great princes and great statesmen, as many great wits, dis-esteem, or at least neglect the scripture. And indeed, though I am sorry it cannot, yet it must not be denied, that notwithstanding all the prerogatives of the Bible, there needs not much acquaintance with great men, to shew many of them, that though they deny not God to be the author, deny themselves the blessing of being readers of it, some out of laziness, and others out of pride; both which lurk under the pretext of multiplicity of important avocations. But since your quality, *Theophilus*, and station in the world, may either make you need to be armed against this temptation, or give you opportunities to assist those that are endangered by it, give me leave, on this occasion, to tell you, that those grandees, that pretend want of leisure for their neglect of the reading of the scripture, must be able to give a rare account of all the portions of their time, to make those pass for a mis-employment of it, that are laid out towards the purchase of a happy eternity; which it is not over-modest for those to expect from God, that grudge him the rent of that time, of which they are but his tenants at will. But to manifest how unlikely this pretence is to pass current; I shall represent, that in the self-same chapter, where God fashions a king fit to govern his own people, he enjoins concerning the book of the law, that *it shall be with him, and he shall read therein, all the days of his life*; which the next verse intimates shall be thereby prolonged. And indeed, it often happens, that as *Samuel's* barren mother for lending one of her children freely unto the Lord, was blest with many others; so the days consecrated to God's service rather improve than impoverish our stock of time. Nay, the king was (in that place of *Deuteronomy*) not only obliged to read the law, but to write it too: upon which subject, if I mis-remember not, the learnedest of the Rabbies tells us, that the king (as indeed God usually charges eminence of place with eminence of piety) was bound to write it out himself, and that, as king. For though before his ascending the throne, as any other Israelite, he had a transcript of his own writing; yet was there annexed to the acquist of the regal scepter, a duty of copying with the same hand that swayed it. To *Jeshua* both a general and a judge, who was to wield the swords both of *Astræa* and of *Bellona*, to govern one numerous people, and conquer seven; the words of God are very remarkable: *This book of the law shall not depart out of thy mouth, but thou shalt meditate therein day and night, that thou mayest observe to do according to all that is written therein; for then thou shalt make thy way prosperous, and then thou shalt have good success*. *David* was a shepherd, a conqueror, and a king, and had certainly no unfrequent distractions, both before he came to the crown, (whilst he lived a despised younger brother, an envied courtier, a dissident fugitive, and a distrusted captain) and after, whilst he wore, lost, and regained it: but how little the time employed in the study of the scripture prejudiced his secular affairs,

affairs, his story and successes may attest; and how large a portion of his time that study shared, you may be plentifully informed by himself, and save me the transcribing much of the book of *Psalms*. He gathered bays both on *Parnassus* and in the field of honour; and equally victorious in duels and in battles, his exploits and his conquests were such, as (transcending those in romances almost as much in their strangeness as their truth) needed an infallible historian to exact a belief, their greatness and their number would dissuade. He added to his regal crown of gold two others (of bays and laurel) which his successful sword and numerous pen, making him both a conqueror and a poet, gained him from victory and the muses. And yet for all this greatness and this fame, and that multitude of distractions that still attends them, the (then extant) scripture was so unseveredly his study, and he so duly matched in his practice what the Apostle couples in his precept, *diligence in business*, and *servency in spirit*, that it is not easy fittier to resemble him, than to the winged cherubims in the old tabernacle, whom all the gold and jewels, that glittered about them, and all the clouds of incense fumed before them, could never divert from a fixed posture towards the ark of the testimony, that contained the law, and the mercy-seat that represented Christ. And indeed, it is a saying equally ancient and true, that none should know (things better and) better things than princes; for their virtues and their vices participate the eminence and authority of their condition; and by an influential exemplariness, so generally fashion and sway their subjects, that as we find in sacred story, that the Jews served God or *Baal* as their kings did, so profane history tells us, that *Rome* was warlike under *Romulus*, superstitious under *Numa*, and so successively moulded into the dispositions of her several princes; subjects, all the world over, being apt to think imitation a part of the duty of obedience; and being generally but too sensible of the requisiteness of their being like their prince to the being liked by him. A state, like *Nebuchadnezzar's* mysterious image, should have the head of gold; and the inferior members of a value proportionate to their vicinity to that noblest part. When once I shall see such monarchies and common-wealths no rarities, and see the addictedness of princes to the study of scripture further the ulterior accomplishment of that part of it, which once promised God's people, *that kings should be its nursing fathers, and their queens its nursing mothers*; I shall expect to see the golden age elsewhere than in poets dreams. For I take not absoluteness to be like a plague, whose almost boundless power is confined to do mischief; but I esteem sovereignty little less applicable and effectual to good than ill. *Trajan* and *Constantine* were as great and publick blessings, as *Nero* or *Caligula* were mischiefs; and virtue on a throne hath not a much less imperious influence, than crowned vice. And accordingly I shall permit my good wishes for mankind to turn expectations, when I shall generally see sovereigns nobly contend for as great a superiority over each other by their virtues, as they possess over their subjects by their fortune; when I shall see potentates make use of *Mars's* sword but to restrain others from abusing it; and kings affect their resemblance to God, less in his unlimitedness of power, than his employment of it. But, to step back into my way, and leaving princes to fitter monitors, say something to men of either great titles or employments. There is none of these pragmatikal persons, that will suffer himself to be so enslaved to his business, but he will allow himself set times, and can daily find leisure for eating, drinking, and other corporal refectations, and frequently for recreations: and certainly, if we valued not our bodies above our souls, we would, in spite of the urgency of secular affairs and employments, reserve and set apart some time to feed our souls with their true food, God's word; else we shall never be able to say of God with holy *Job*, *I have esteemed the words of his mouth more than my necessary food*. I will not urge, that *Daniel*,

Rom. xii.

Deut. xxv.
18, 19, 20,
21.

Dan. ii. 37,
32, &c.

Isa. xlix. 23.

Psal. cxlii.

Job xxiii.
12.

whose

Dan. vi. 3.

Dan. ix. 2.

Isaiah xl.
23, 27.Dan. x.
23.2 Kings
xix. 35.second Jer.
31. 1. 22.

whose vast abilities had a resembling theatre, and who surpassed other statesmen as much in the number and weight of the affairs he had to manage, as in the excellent spirit and dexterity, wherewith he managed them, amidst transactions that busied six-score princes, who loaded him with a weight (of business) capable to have crushed *Atlas*, could yet find leisure to study the prophet *Jeremy*; because it will be perhaps more proper to mention, that even *Machiavel* himself, that secretary and reputed oracle of state, could find time, not only to read, but to write plays, (some of which I have seen in Italian) such as I would think excellent, though a person, from whom so much might be expected, had not written them. Let us not then think our business or our recreations a sufficient dispensation from an employment, for which, were they inconsistent, they ought both to be declined; since it is both more concerning than the first, and more satisfying than the latter. But that, which is often the true, though seldom the avowed cause of these men's neglect of the scripture, is not their unlearnedness, but their pride; which makes them think it too mean and trivial an employment for one, that is great and wise enough to counsel and converse with princes; and have a vote or hand in those great enterprizes and transactions, that make such a noise in the world, and are the loud themes of the people's talk and wonder, to amuse themselves to examine the significations of words and phrases. For my part, I am no enemy to the calling of statesmen; I think their profession as requisite as others in a common-wealth; and should think it very injurious to deny them any part of a purchase they pay their care and time for: nor perhaps have I so little studied the improvements of quiet, as to think my self less obliged than others are to those, whose watchings or protection affords it, or secures it to me. But after all this is said, I love to look upon the world with his eyes, that is justly said to *bumble himself* (when he vouchsafes) *to behold the things that are done in heaven and in earth*; and to take measure of the dimensions of things by the scale his word holds forth. Now in the esteem of him, that hath made all things for himself, and of whom his spirit by his prophet truly says, that the *nations are as a drop of a bucket, and are counted as the small dust of the balance*; nay, that *all nations before him (are) as nothing, and they are counted to him less than nothing and vanity*; the importantest employments are the study and glory of God. He created this vast fabrick of the world to manifest his wisdom, power, and goodness; and in it created man, that it may have an intelligent spectator, and a resident, whose rational admiration of so divine a structure may accrue to the glory of the omniscient and almighty architect. And as he created the world to manifest some of his attributes, so doth he uphold and govern it to disclose others of them. The revolution of monarchies, the fates of princes, and destinies of nations, are but illustrious instances and proclamations of his providence. The whole earth once perished by water, to signalize his justice on his enemies; and the whole world shall one day perish by fire, to (exercise that former attribute and) evidence his goodness to his children: for whom his faithfulness to his promises will oblige him to build a gloriouſer mansion for such glorified residents. The angels, some of whom the visions of *Daniel* represent to us at the helm of kingdoms and of empires, and whose power is so great, that one of them could in one night destroy a force, capable, if divided, to have made half a dozen formidable armies; these glorious spirits, I say, whose nature so transcends ours, that the very devil cannot, without the assistance of virtue, despise the objects of our ambition by a superiority of nature only; for all their high prerogatives and employments, think the mysteries unfolded in scripture worthy their bowing as well as desire to look into; think not themselves too eminent to be messengers and heralds, of which fond mortals think themselves too eminent to read; and

and (being all *ministring spirits sent forth to minister to them who shall be heirs of salvation*;) disdain not to think our instruction worth their concern, whilst we disdain a concern for our own instruction. Nay, the very *Messias*, whose style is *king of kings*, and *lord of lords*, though he be not recorded to have ever read but once, did yet read the scripture, and think it worthy his expositions and recommending; and well may any think that book worth the reading, that God himself thought worth enditing. When *Moses* and *Elias* left their (local, not real) heaven, and appeared in glory to converse with our transfigured Saviour on the mount; their discourse was not of the government of kingdoms, or the raising of armies for subversion of empires; or of those other solemn trifles, which heaven places as much beneath men's thoughts as residence; but of (the inspired book's chief theme) *his decease, which he should accomplish at Jerusalem*. And after that St. Paul *had been caught up to the third heaven*, and had been blest and refined with his ineffable entertainment there; I wonder not to find him profess so resolutely, that he *counteth all things but loss for the excellency of the knowledge of Christ Jesus his Lord*, in whom *faith cometh by hearing, and that hearing, of the word of God*; and who addresses men to the scriptures, as those which testify of him. And perhaps our Saviour used so frequently to conclude his divine discourses with that just epiphonema, *he that hath ears to hear, let him hear*, but to teach us, that there is no employment of our faculties, that more deserves their utmost attention, than the scrutiny of divine truths. That which is pretended to by this discourse, is to impress this truth, that where God is allowed to be an intelligent and equal valuer of things, a man cannot have so great an employment, as to give him cause to think the study of the scripture a mean one; since, thus saith the Lord, *Let not the wise-man glory in his wisdom, neither let the mighty-man glory in his might; let not the rich man glory in his riches: but let him that glorieth, glory in this, that he understandeth and knoweth me*. For sure, if the knowledge of God be so glorious a thing, the study of that book, whence that knowledge is extracted, and where it is most resplendent, is not a despicable employment. Which sure (to add that upon the by) it is somewhat injuriously thought by those, who are so industrious and proud in profane histories and other political books, to discover (or even guess at) those intrigues, which commonly but tell us, by what crafty arts a knave couzened a fool. Nor (to mention this by the by) even in relation to his own profession, is the scripture unable to recompence the study of a Christian statesman; for to omit the (perhaps too) extolling mention *Machiavel* himself makes of *Moses* amongst the famouslest legislators; the historical part of the Bible being indited by an omniscient and unerring spirit, lays clearly open the true and genuine causes of the establishment, flourishing and vicissitudes of the princes and common-wealths it relates the story of. Whereas other histories (for reasons insisted on in other papers) are liable to great suspicions in the judgment of those, that duly ponder the several narratives made often of the same transaction or event by several eye-witnesses; and that the true secret of counsels is so closely locked up, or so artificially disguised, that to have interest enough to discern (what statesmen mind and build on) the truth and mystery of affairs, one must be biased and engaged enough to be shrewdly tempted to be a partial relator of them. But, *Theophilus*, I perceive I have slipped into too long a digression; which yet I hope you will pardon as the effect of an indiscreet, perhaps, but however a great concern for a person, to whom nature, education, and fortune have been so indulgent, that I cannot but look upon his condition as liable to the temptations, which either parts or employments singly, and much more both together, are wont to expose men to.

Heb. i. 14.

Rev. xvii.

14.

Luke iv.

17, &c.

Luke ix. 37.

2 Cor. xii.

2.

Phil. iii. 8.

Rom. x.

17.

John v.

39.

Jer. xix.

23, 24.

The apostle
is for and
against
of Roman-
ces.

The fifth
and last
answer to
the last
objection.

You may remember, *Theophilus*, that among the answers, which, I told you, might be made to those, that objected against the scripture, *That it is so unadorned, and so ill furnished with eloquent expressions, that it is wont to prove inefficacious, especially upon intelligent readers*; the fifth and last was this, *That it is very far from being agreeable to experience, that the style of the scripture does make it unoperative upon the generality of its readers, if they be not faultily indisposed to receive impressions from it.*

To make good this reply, I must take notice to you, that that part of the objection, which intimates, that intelligent readers are not wont to be wrought upon by the scripture, has been in great part answered already: for I have lately observed to you, that as it may be granted, that some witty men, who have read the scripture, have, instead of admiring it, quarrelled with it; so it cannot be denied, that many persons as eminent for wit as they, have, upon reading it, entertained a high veneration for it. So that I see not, why the celebrations of those wits, that admire it, may not counter-balance the dis-respects of those, that cavil at it; especially if we consider, that as to most of those, that are looked upon as the witty disregards of the scripture, scarce any thing, so much as the vanity and boldness of owning that they disregard it, makes them (but undeservedly) be looked upon as wits.

BUT to this I shall now add, that whereas the objection speaks of intelligent readers, the greatest part of such have not that quickness, which is wont to make men pass for wits, though they may have other abilities more solid and desirable: and yet that the Bible has a great influence upon this latter sort of intelligent readers, I presume you will easily believe, if you consider how many great scholars, not only professed divines, but others, have by their learned comments and other writings, endeavoured either to illustrate, or recommend the scripture; and how much a greater number of understanding and sober men, that never published books, have evinced the scripture's power over them, partly by their sermons and other discourses, publick and private; and partly by endeavouring to conform their lives to the dictates of it. Which last clause I add, because you can scarce make a better estimate of what power the scripture has upon men, than by looking at what it is able to make them part with. For not to anticipate what we shall ere long have occasion to mention, let us but consider, what numbers of intelligent persons almost every age, without excepting our own (as degenerate as it is) has produced, who have been taught and prevailed with by the scripture, and considerations drawn thence, to renounce all the greatest sinful pleasures, and embrace a course of life, that oftentimes exposes them to the greatest dangers and very frequently to no small hardships.

AND indeed there is scarce any sort of men, on which the scripture has not had notable influence, as to the reforming and proving many particular persons, belonging to it; and to the giving them an affectionate veneration for the book, whereunto they owed their instruction. The accounts ecclesiastical history gives us of the rate, at which devout persons, both in former and latter ages, would purchase the Bible, when it was dangerous and perhaps capital to be found possessed of it, would, if I should here repeat them, much confirm what I say, and might equally create our wonder and our blushes. Those sorts of professed Christians, that seem the most evidently to be liable to temptations to neglect or disregard the scripture, are either those, that do, or would pass for wits, or those that live in courts; the former oftentimes thinking themselves too wise to be taught, especially by a book they think not eloquent, and among the latter there being but too many, whose pleasures are so bewitching, or so dear to them, that they like nothing, that would divert, much less divorce them from their pursuit; or else whose business is so much, and perhaps so important,

important, that they have not leisure enough to learn, or have too much pride to think they need do it. But yet even among those, that have worn crowns either of gold or bays, or (what perhaps some value above both) of myrtle, the Bible has not wanted votaries: for not to repeat the names of those, whom I have formerly mentioned to have been as well lovers of the scripture, as favourites of the muses, among the other sort of men, *those that* (to speak in our Saviour's terms), *are gorgeously apparelled, live delicately, and are in kings courts*, there have been divers persons, upon whom the power of the scripture has been almost as conspicuous, as their station among men. I will not mention that devout treasurer of the *Ethiopian* queen, who even upon the high-way (whose length neither deterred nor tired his devotion) could not forbear to read the prophet *Isaiah*, and inquire even of a meer stranger, that passed by alone, and on foot, the meaning of a passage, of whose sense he doubted; nor will I urge any other instances of great men's studiousness of the scripture, afforded us by sacred story. And therefore I shall not press the example of that great and wise *Daniel*, whose matchless parts not only cast upon him the highest employment of the world's monarchy, and disengaged him from the ruins of it; but (what has scarce a precedent amongst the very wisest statesmen) continued him in as much greatness, as ever he possessed under the predecessor, under the successor; and such a successor too, as made his predecessor's carcass the ascent to his throne: I will not, I say, at present urge the examples extant in the sacred records of great men's studiousness of them, because even secular and more recent histories may inform us, that even in courts all men's eyes have not been so dazzled by the glittering vanities, that are wont to abound there, but that some of them have discerned, and practically acknowledged the prerogatives of scripture. Though I cannot say, that many kings have been of this number, because there have been but few kings in all, in respect of the numbers, that compose the inferior conditions of men; yet even among these, and in degenerate ages, some have been signally studious of the Bible; such was that sixth *Edward*, who imitated the early active piety of *Joash*, without imitating his defection from it, and whose short heavenly life manifested, how soon, even amidst the temptations of courts, grace can ripen men from glory. And such was that learned king, whose having more than perfunctorily studied the scripture, his solid defence of divers of its truths against his mis-interpreters have sufficiently proclaimed to the world. Nay, even in those darker times, that preceded the reformation, that excellent Aragonian king, *Alphonfus*, the honour both of his title and his times, in spite of his contemplations and his wars, could (as himself used to glory) spare time from studies and his distractions, to read the Bible forty times with comments and glosses on it; being not, for all his astronomy, so taken up with contemplation of heaven, as to deny himself leisure to study in his book, that made it, the ways of getting thither. Nor shall I forbear to mention here the last pope, (*Urban* the eighth) who, when being cardinal, he wanted not the hopes of becoming both temporal and ecclesiastical lord of that proud city, which (as if she were designed to be still, one way or other, the world's mistress) doth still rule little less of the world upon the score of religion, than she did before upon that of arms; in the midst of affairs, perhaps more distracting than busied most potentates, and honours almost as great as are paid to monarchs, could find room in a head crouded with affairs enough to have distressed *Machiavel*, for reflections upon the scripture; some of whose portions I have delighted to read in the handsome paraphrases of his pious muse. Which I scruple not to acknowledge, because that though I did, which I do not, look upon every one, that dissents from me, as an enemy; yet I should be apt to think, that they can scarce love virtue enough, that love it not in their very enemies; congruously to which we

Luke vii.
25.

King
James,

Eudoxia,
wife to the
Emperor
Theodosius.

find that *Hannibal* had statues erected in *Rome* itself; and though I were so uncharitable and so unexperienced as to think a man, that holds an error, can scarce have any good qualities; yet upon such a kind of score as that, which made *David* so angry with him, that took away the poor man's single lamb, the fewer commendable qualities I see in my adversaries, the more scruple I would make to rob them any way of them. Nor hath that very sex, that so often makes divertisements of its employments, been altogether barren in titled votaries to the scripture. Not to mention that Grecian princeſs, whose profelyted muse made *Homer* turn evangelist, how conversant that excellent mother and resembling daughter, *Paula* and *Eustochium*, were in the sacred rolls, is scarce unknown to any, that are not strangers to the writings of St. *Hierome*; for some of whose learned comments on the scripture we are endebted to the charitable importunity of their requests. And even in our times, that so much degenerate from the primitive ones, how eminent a student and happy a proficient in the study of the Bible, that glory of princeſſes, and the envy of the princes of her time, queen *Elizabeth*, was, her life and reign sufficiently declare. Her sister's predecessor, that matchless lady *Jane*, who had all the good qualities the best patriots could desire in a queen, but an unquestionable title, and in whose sad fate, besides her sex and the graces, that enamour ours of it, her country, philosophy, virtue, and religion, did all sustain a loss, was a conspicuous studier of the inspired books; wherein her prospered sedulousness gave her an understanding much above her age and sex, though not above her virtue. And besides *Eudoxia*, there have been divers other persons of the highest quality of that sex, and even some of those, on whom nature or fortune, or rather beauty or providence had conferred a sovereignty, whom the splendour, the pleasures, nor the avocations of courts could not keep from searching in God's word preservatives against the contagion of their condition. And partly history, and partly even conversation have sometimes with delight made me observe, how some of those celebrated ladies, whose fatal beauties have made so many idolaters, have devoutly turned those fair eyes, that were, and did such wonders, upon those severe writings that depreciate all but the beauty of the soul, from those flattering ascriptions, that deified the body. And it is not to be marvelled at, that such readers as are not infidels, by reading the Bible once, should be prevailed with to read it oftener; not only because of the inviting excellency of what it teaches, but because its author does so earnestly in it enjoin the study of it, that scarce any can think the neglect of it no fault, save those that are guilty of it. Nor is their so assiduous perusal of the scripture so much to be marvelled at as commended, in persons of that softer sex, which is perhaps more susceptible than ours of strong impressions of devotion. For sure, if we loved God, I do not say as we ought to love him, but as we can, and do love inferior things, it would hugely endear the scripture to us, that the object of our devotion is the author of that book. When a true flame, though but for a fading object, doth once possess a fervent lover's breast, what a fondness doth his passion for his mistress give him for all things related to her? Her residencies, her walks, her colours, and the least trifles that have belonged to her, exact a kindness that's not due to trifles: though it be but for presenting to his memory its almost only object, and refreshing him with an ideal in the absence of an immediater presence of her. But if the favoured amourist be blest with any lines dignified by that fair hand, (give me leave to talk of lovers in their own language) especially if they be kind as well as hers, how assiduously, and with what raptures do his greedy eyes peruse them, tasting each several expressions with its own transport; and finding in each line, at each new reading, some new delight or excellency? This welcome letter grows sooner old than stale; and all his too frequent kisses have worn

t to tatters, (in which he preserves it, if not worships too, as a relic) with still fresh and still insatiate avidities doth the unwearied lover prize that (too often, either deluding or insignificant) writing, above the noblest raptures of poets, and liberallest patents of princes: and (not to urge the superstitious devotion of our worshippers of relics) certainly if we had for God but half as much love as we ought, or even pretend to have, we could not but frequently (if not transportedly) entertain our selves with his leaves, which (as parrhelions to the sun) are at once his writings and his picture; both expressing his vast and unmerited love to us, and exhibiting the most approaching or least unressembling idea of our beloved, that the Deity hath framed for mortals to apprehend. It was the devout quarrel of a devout father to some of the choicest composures antiquity hath left us, that he could not find Christ named there; and if, as it is not to be doubted, divers of the devout ladies I was lately speaking of, were of his mind, sure at that rate they are not ordinarily kind to the scripture; where the Prophets and the Apostles, those darker and more clear Evangelists, do so unanimously and assiduously celebrate the Messiah, that when I read and confer them, I sometimes fancy my self present at our Saviour's triumphant entrance into *Hierusalem*, where both *those that went before him, and those that followed after him, sung hosannab to the son of David*.—Wherefore, since even great wits, great princes, and great beauties, have not still by all those temptations, to which these attributes exposed them, been kept from being also great votaries to the scripture, it cannot charitably be doubted, but that in most ages some pious persons have been able to say truly to God in *Jeremy's* terms, *Thy words were found, and I did eat them; and thy word was to me the joy and rejoicing of mine heart*. And if the persons I mention have been but few, I can attribute that fewness but to the paucity of wise and good men; and as for persons of other ranks in ecclesiastical stories, the instances are not so rare of the addictedness of God's children to his word, but that we might thence produce them almost in throngs, if we had not nobler inducements to the reading of the inspired volume than example; and if it were not less to be venerated, because so many saints have studied it, as because the study of it made many of those men saints, (I mean not nominal, but real ones:) which we need not much wonder at, whilst such a saint as *Saint Paul* was assures us, that it is all of it divinely inspired, and improveable to all the uses requisite to the entire accomplishment of God's servants. But, *Theophilus*, to return to what I was formerly discoursing of, the transforming power the scripture has upon many of its readers; I must subjoin, that though through the goodness of God these be far more numerous than the professed adversaries and contemners of the scripture, yet these make not so great a part of those, that acknowledge the Bible, as it were well they did, because both experience and our Saviour's parable have sufficiently taught us, that good seed does not always fall into good ground, and that many intervening accidents may, after it has been sown, make it miscarry and prove fruitless. But when you find (as I fear you may but too often) that the scripture has not upon its readers, and especially upon those that are profane, that power, which I seem to ascribe to it, and which it ought to have; you may be pleaded to remember, that I plainly suppose in my fifth answer, that those, to whom the scripture is addressed, must not be culpably indisposed to be wrought upon by it. Which that profane persons are, I presume you will easily grant: for when our Saviour said, that *if any man will do the will of him that sent him, he shall know of the doctrine, whether it be of God, or no*; he clearly intimates, that there is required a disposition as well in the eye of his soul, (if I may so speak) as in the object proposed, to make a man discern the excellency and origination of what is taught, how valuable soever. *St. Paul* speaking of himself and other

Mat. xxi.

9.

Mark xi.

9.

Jerem. xv.

16.

2 Tim. iii.

16.

John vii.

17.

1 Cor. ii.
7.

Prov. xiv.
6.

Gen. xix.
5, 11.

other penmen and teachers of the scriptures, affirms, that they speak wisdom among them, that are perfect, and (though not this world's wisdom, yet) *the wisdom of God in a mystery, even that hidden one, which God ordained before the world, unto our glory.* But for these scorers, it is no wonder they so fruitlessly read the scripture, without deservyng any of this mysterious wisdom, it being a sentence of the scripture it self, *that a scorner seeketh wisdom, and [findeth it] not,* (the expression is odd in the original, but I must not stay to descant upon it;) as the Sodomites could not find the angels, when once they sought them to prostitute and defile them.

Heb. iv.
2.

Tit. ii. 12.

Mark xii.
37.

BUT besides profane wits, there are too many other readers, who are (more or less) guilty of opposing the reforming and improving influence of the scripture, upon their own hearts; either upon the score of their not sufficiently believing the truths contained in the scripture, or upon that of their not duly pondering them. That unbelief is the fruitful mother of more sins than are wont to be imputed to it, and that many baptized persons are not free from greater degrees of it, than they are suspected of by others, or even by themselves, I could here easily manifest, if I had not professedly discoursed of that subject in another place. And indeed, there needs but a comparing of most men's lives with the promises and threats held forth in the scripture of no less than everlasting joys and endless torments, to make us believe, that there are multitudes of professed Christians, to whom may be applied what the writer to the Hebrews says of the perverse Jews of old, *That what they heard did not profit them, not being mixed with faith in them that heard it,* or (as the Greek will bear) because they were not united by faith to the things they heard. But this is not all, for oftentimes the doctrines of the scripture lose much of their efficacy, even where they are cordially believed, because they are not sufficiently laid to heart. The disparity of the influences of the bare belief and the due perpenion of a truth is, methinks, conspicuous enough in men's thoughts of death. For though that they shall die is so truly believed, that it cannot seriously be doubted; yet how doth men's inadvertency make them live here, as if they were to do so always? Whereas when once grace, sickness, the sight of a dying friend, or some other tragick spectacle, hath seriously minded them of death, it is amazing to observe, how strange an alteration is produced in their lives by the active and permanent impresson of that one obvious and unquestioned truth, that those lives must have a period; and to see how much the sober thoughts of death contribute to fit men for it: it being so imperious an inducement to deny ungodly and worldly lusts, and to live *σωφρόνως καὶ δυνάτως δὲ εὐσεβῶς ἐν τῇ νῦν αἰῶνι, soberly, righteously, and godly in this present world,* that we must one day leave it; that I admire not much that father's celebrated strictness and austerity, who tells us, that he fancied always founding in his inward ears, that dreadful alarm of, *Surgite mortui, & venite ad judicium.*

YET notwithstanding the indisposition of many readers to reverence and obey the scripture, and notwithstanding that in divers passages of it, the ornaments of language are (for reasons above specified) purposely declined; yet we find not, but that the scripture, for all these disadvantages, is by the generality of its readers both esteemed and obeyed at another-guise rate, than any other book of ethicks or devotion. And multitudes even of those, whose passions, or interests, will not suffer them to be in some points guided by it, are notwithstanding swayed by it, to forbear or practise divers things, in cases wherein other books would not prevail with them. As *Herod*, though the Baptist could not persuade him to quit his *Herodias*, did yet, upon *John's* preaching, do many other things, and *heard him gladly.*—I was going to say, that we may not unfitly apply to the word of God, what divines have observed of God the

word; for as those accidents, that loudliest proclaimed our Saviour's having assumed our human nature and infirmities, were attended with some circumstances, that conspicuously attested his divinity; so in those passages, in which the majesty of the author's style is most veiled and disguised, there is yet some peculiarity that discloses it. But I shall less scruple to tell you, that in divers of those passages, in which the Holy Ghost (who in the Greek fathers wonted expression does often συγκαταβαίνειν ἡμῖν, stoop to our capacity, and, as it were, sink himself down level) seems most to have vouchsafed a condescension to the style of men; and to have commanded his secretaries, as he once did the prophet *Isaiab*, to write, *בְּחֵרֶט אָנֹכִי* *Be-chææt Enosh, with a man's pen*; in divers of those very places, I say, there is something of so awful, and so peculiarly his, that as the sun, even when he descends into the West, remains still lucider than any of the stars; so the divine inspirer of the scriptures, even when his style seems most to stoop to our capacities, doth yet retain a prerogative above merely human writings. *Known unto God are all his works from the beginning of the world*, says an Apostle; and God, whose attribute is to be *καρδιογνώστης, the knower of hearts*, and whose prerogative it is to *form the spirit of man within him, understandeth our thoughts afar off*. Certainly then, if we consider God as the creator of our souls, and so likeliest to know the frame, and springs, and nature of his own workmanship; we shall make but little difficulty to believe, that in the book written for, and addressed to men, he hath employed very powerful and appropriated means to work upon them. And in effect, there is a strange movingness, and, if the epithet be not too bold, a kind of heavenly magick to be found in some passages of the scripture, which is to be found no where else; and will not easily be better expressed, than in the proper terms of the scripture: *For the word of God, (says it) is quick and powerful, and sharper than any two-edged sword, piercing even to the dividing asunder of soul and spirit, and of the joints and marrow, and is a discerner of the thoughts and intents of the heart*. Wherefore, that *Junius* (as himself relates) was converted from a kind of atheist to a believer, upon the reading the first chapter of *John*; that a Rabbi, by his own confession, was converted from a Jew to a Christian, by the reading of the fifty-third of *Isaiab*; that *St. Austin* was changed from a debauchee into a saint, by that passage of the 13th to the *Romans* and 13th verse; and that another father, whose fear had made him disclaim his faith, burst out publicly into a shower of tears, upon the occasional reading of the 16th verse of the 50th *Psalms*; are effects, that I do not so much admire, as I do, that such are produced no oftener. And truly for my own part, the reading of the scripture hath moved me to more, and swayed me more powerfully to all the passions it would infuse, than the wittiest and eloquentest composures, that are extant in our own and some other languages. Nay, so winning is the majesty of the scripture, that many (like those that fall in love in earnest with the ladies they first courted, but out of, what the French call gallantry) who began to read it out of curiosity, have found themselves engaged to continue that exercise out of conscience: and not a few of those, that did at first read the new testament only to learn some unknown language it is translated into, or for some such trivial purpose, have been by the means, that they elected, carried beyond the end that they designed, and met a destiny not ill resembling that of *Zacheus*; who climbing up into a sycamore growing in our Saviour's way, only to look upon him, passed thence to be his proselyte and convert, and to entertain him joyfully both in his house and heart. And though it be true, that the church's testimony be commonly our first, yet it is not always our chief inducement to believe the divinity of Holy Writ; its own native prerogatives heightening that into faith, which the church's authority left but opinion. To which purpose, I remember a handsome observation of some of the ancients; that the Samaritans,

Isa. viii. 13.

Acts xv. 13.

Acts i. 24.
Zech. i. 13.
Psal. xlii. 2.

Heb. iv. 12.

Luke xix.
à ver. 1.
ad ver. 10.
Mat. xlii.
19, 20, &c.

that

John iv.
39-42.

1 Cor. ii.
3-4.

Wet. 3.

The conclusion of one part of the discourse, concerning the scripture; and the transition to the next.

that first believed in Christ upon the woman's report, when afterwards they were blessed with an immediate conversation with himself, they exultingly told the woman, *now we believe, not because of thy saying; for we have heard him our selves, and know that this is indeed the Christ, the Saviour of the world.* For so, divers, that first believe the scripture but upon the church's score, are afterwards by acquaintedness brought to believe the scripture upon its own score; that is, by the discovery of those intrinsic excellencies and prerogatives that manifest its heavenly origination. — This sacred book, even where it hath not embellishments of language, doth not want them; being so much recommended by its imperious persuasiveness without them, that it is more ennobled by their needlessness, than it would be, by their affluence. And if to some passages of scripture we must apply that of St. Paul, (whereby yet he thought to recommend his ministry to the Corinthians) *That his speech and his preaching was not with the enticing words of man's wisdom, but ἐν ἀποδείξει πνεύματος καὶ δυνάμεως*, we may also remember, that he subjoins as the reason, that moved him to use this plain and unadorned way of teaching his Corinthians, *That their faith might not stand in the wisdom of men, but in the power of God.* And truly the efficacy and operations of the Bible, in comparison of those of all other books, duly considered, we may esteem, that as God oftentimes doth in the scripture, what in the scripture he is said to do, draw us with the cords of a man, (passages wreathed with flowers of rhetorick) so is it not unfit, that we should sometimes employ expressions, that carrying away our obedience, our reverence, and our assent in spite of our indispositions to them, might manifest their derivation from him, who is not tied to such means, as men would think necessary, but can compass his ends as well by as without any. Nor can I often consider the instances experience affords us of the efficacy of many texts, (which some that pretend to eloquence accuse of having none) without sometimes calling to mind, how in the book of nature God has veiled in an obscure and homely stone an attractiveness (unvouchsafed to diamonds and rubies) which the stubbornest of metals does obsequiously acknowledge. And as the loadstone not only draws what the sparklingest jewels cannot move, but draws stronglier where armed with iron, than crowned with silver; so the scripture not only is movinger than the glitteringest human styles, but hath oftentimes a potenter influence on men in those passages, that seem quite destitute of ornaments, than in those, where rhetorick is conspicuous.

I SHOULD NOW, *Theophilus*, immediately pass on to the other things I am to discourse to you of, concerning the scripture, but that the curiosity, wherewith you are wont to take notice of my practices, and to make inquiries after my private opinions, makes me imagine you telling me, that I do often read, and do much oftener commend books of devotion, notwithstanding all the prerogatives I have attributed to the scripture: wherefore to this I shall answer, that I esteem indeed the truths of scripture so important and valuable, that I cannot be troubled to see them presented to us in variety of dresses, that we may the more frequently and the more attentively take notice of them. And though some devout composures are so unskilfully written, as to be much fitter to express the devotion of the writer, than to excite it in the reader; yet there are others so handsomely and so pathetically penned, that a good man can scarce read them without growing better, and even a bad man must be very much so, without becoming less so by perusing them. Nor do I at all design to disparage books of devotion, when I prefer the scripture to them, that being so noble and mat-hless a work, that a book may attain to a high degree of excellence, whilst it remains inferior to the scripture, and of whose preheminencies I have already on several occasions named divers to you; and therefore shall at present only recommend to your observation this one advantage of the scripture, even as to those things, that

are

are also to be met with in other books of devotion; That if *the words of the wise be* (as Solomon tells us they are) *like nails fastened by the masters of the assemblies*, the self-same nail must enter less or deeper, according to the strength of the hand that drives it in; and doubtless, any doctrine believed to come from God, in the same terms it is delivered to us, is like to be entertained with a deeper and obsequiouser respect; concurrently whereunto, the Apostle, to set forth the Thessalonians reception of the gospel, says, *That they received it not as the word of men, but (as it is in truth) the word of God.* After which, it is no wonder he could immediately subjoin, that it did also effectually work in them that believed. And though it be very true, that the foreignness and obscurity of some texts will require, as well as the teeming richness of others will bear, their being alledged in words much more numerous than those, whose involved or contracted senses they are to display; yet is it also as true, that men do not unfrequently mistake themselves in thinking to deliver the Holy Ghost's conceptions in fitter terms than his own, the proper precise expressions of scripture being oftentimes so pathetical and sinewy, that he, that stretches them, enervates them; and paraphrases, though handsome, do as much wrong them, as a mixture of silver, though no ignoble metal, does wrong an ingot of gold. And though some texts like pearls lose indeed of their beauty; but operate, and are administered more successfully beaten to powder, or with other cordial ingredients made up into a confection; yet divers sacred expressions do like diamonds lose both their sparkling lustre, and engraving faculty, when ground to dust, and lose more in their entireness and form than can be recompensed by any addition. And truly, as to my own particular, no book of devotion doth constantly affect me so powerfully as the Bible. And whereas I am of so nice a palate, that in my esteem compositions of that kind still lose at the second reading; in the inspired volume, familiarity breeds not contempt, but reverence (and I like a book, acquaintance still endears). When I first began attentively to read the scripture, and (according to my custom when I read books, whereof I have a promising expectation) to mark in the margin the passages, that seemed to deserve a peculiar notice or reflection, I marked but here and there some verses in a chapter; but when, upon a greater familiarity with the idiotisms, the sense, and the applicableness of scripture, I came to survey it, I then in some places marked the whole chapter, and in most others left much fewer texts than before unfurnished with some mark of reference. And whereas at my entrance I took even the choicest part of the Bible to be at best but like some Indian province, wherein though mines and gems were more abundant than in other countries, yet they were but sparingly to be met here and there: after a competent stay, my ensuing perusals presented it me, if not as a royal jewel made up of gold and precious stones, yet (which is gloriously) like Aaron's breast-plate, a sacred jewel, the particular instructions for which, were given by God himself, and which, besides the various number of flaming gems set in fine gold, and placed in a mysterious order, was ennobled by that *Urim and Thummim*, wherein God vouchsafed to reveal himself to mortals, and was adorned with so much cunning work in gold, blue, purple, scarlet, and fine twined linen, that the contrivance and workmanship lent a lustre to the glittering materials, without being obscured by them. This experiment keeps me from wondering to find in the inspired poet's description of the man he attributes a blessedness to, that his *Chaphatz* is in the law of the Lord, and in his law will be meditate day and night. For the word other translations render *voluntas & studium*, ours Englishes delight; and indeed the Hebrew חפץ will bear both senses, and seems there emphatically to signify a study replenished with so much delight to the devout and intelligent prosecutors of it, that, like the hallelujahs of the blessed, it is at once a duty and a pleasure, an exercise and a recompence of piety. And indeed, if

Eccles. xii.
11.

1 Thess. iii.
13.

Psal. i. 2.

God's blessing upon the devout Christian's study of that book do (according to the Psalmist's prayer) *open his eyes to discern the נכלאות Niplaot, hidden wonders* contained in it; he should, in imitation of him that in the same Psalm says of his God, *I rejoice at thy word, as one that findeth great spoil*, be as satisfied as navigators, that discover unknown countries. And I must confess, that when sometimes, with the Apostles in the mount, I contemplate *Moses* and *Elias* talking with Christ, I mean the law and prophets symphonizing with the gospel, I cannot but (resemblingly transported with a like motive) exclaim with *Peter*, *it is good for me to be here*; and cease to think the Psalmist an hyperbolist, for comparing the transcendent sweetness of God's word to that inferior one of honey, which is like it in nothing more, than in that, of both their suavities, experience gives much advantageously notions than descriptions can.

Mat. xvii. 4.
Psal. cxix.
103.

BUT, *Theophilus*, upon condition you will not call this excursion of your own occasioning a fit of devotion, I will no longer detain you on one subject, but forthwith proceed to discourse of those other things, that I am to consider in the scripture, besides the style. For though this be such as I have been representing it, yet I hope we shall in our progress find, that it will be far less fit to apply to this matchless book than that of the Heathen poet,

Materiam superabat opus ———

Psal. xiv.
23.

than that sacred one of the Psalmist, where he as well says, that *the king's daughter is all glorious within*, as that *her cloathing is of wrought gold*.

OCCASIONAL
REFLECTIONS
UPON
SEVERAL SUBJECTS.

WHERE TO IS PREMISED

A DISCOURSE about such kind of THOUGHTS.

Omnibus rebus, omnibusque sermonibus, aliquid salutare miscendum est. Cum imus per occulta naturæ, cum divina tractamus, vindicandus est à malis suis animus, ac subinde firmandus. Sen. Natural. Quæst. Lib. 2. cap. 59.

To SOPHRONIA*.

MY DEAREST SISTER,

YOU receive, in this effect of my obedience, one of the highest proofs I can give you of its greatness. For when you command but things, that tend to your service, the performance is wont to be accompanied with a satisfaction, that suffers me not to find it uneasy. But I confess it was not without reluctance, that I was prevailed with to venture abroad compositions, wherein, even when I publish them, I decline owning them; and which (if our names be discovered) may, I fear, not only hazard the reputation (if it have any) of my pen; but (where you are less known) bring into question that of your judgment. It was easy for me to represent to you, how unfinished and unpolished the trifles you called for were; especially considering, that the immaturity of some of them would not probably be the chief thing, that would make many think they come forth unseasonably, since they avowedly aim at the persuading and teaching men to improve their thoughts, as well as husband their time, at a season, when both those precious things are so neglected, or so mis-employed, that the chief use, which too many make of the former, is to devise ways to get rid of the latter. But though, to my unreadiness to publish these very long neglected papers; at the same time when a pre-engagement obliged me to dispatch another treatise of a quite different nature, I added all those other dissuading considerations, that I have mentioned in the preface to the reader; yet what I represented proved as unavailable, as what I had written was incomplete. For, whilst you fancied, that the following reflections (such as they are) had fewer faults, and were like to do more good, than I can presume; your charity for others, and partiality for me, made you so resolute and pressing to have me run a venture, which you are pleased to think but a very small one, that I judged it more excusable

* It is the name given to the same lady in the 2d section of the following meditations.

to present you green fruit, than, by obstinately refusing what you seemed almost to long for, lose an opportunity of evincing, that your commands can prevail, both where those of others would have been wholly ineffectual, and when they required me to present you (some, if not many) things, that are so little worthy of you, that perhaps they are scarcely so, even of me.

WONDER not, dear *Sophronia*, that I appear so solicitous to manifest the greatness of my obedience; since that implies an urgency in your commands, that it highly concerns me to have taken notice of. For those, that, having the happiness to converse with you, shall chance to cast their eyes upon the following papers, will probably think, that I shew as little discretion in the address, as I have shewn skill in the writing, of these reflections; when I expose such censurable things to the judgment of a person, that has so piercing a one, and present trifles to one, that deserves the noblest productions of (what she is so great a mistress of) wit, and eloquence. Upon whose account she is wont to persuade piety as handsomely in her discourses, as she expresses it exemplarily in her actions; and might, if her modesty did less confine her pen to excellent letters, both make the wits of our sex envy a writer of hers, and keep our age from envying antiquity for those celebrated ladies, who, by their triumphant eloquence, ennobled the people of *Rome*, and taught their children to sway those rulers of the world.

BUT when I can plead, that not only your commands, but even your importunity engaged me (though not to the address, yet) to the publication of these papers; I may reasonably hope, that among those many considerable persons, to whom your attainments are not unknown, not only my dedication will be excused, but even my book will not be so hastily condemned.

BUT I dare not prosecute so fruitful a subject, for fear of offending your modesty; since that predominant virtue gives you so great an undervaluation for all your other qualities, that it is as much your custom to look even upon small praises as flatteries, as it is your prerogative to keep great ones from being so. And I should therefore have omitted that little itself, which I have said, if, on this occasion, my interest did not as well oblige me, as the known truth warrant me, so to consider your modesty, as not to be altogether injurious to your other excellencies; since the reader's knowledge of these (if he be not a stranger to you) will promise me this advantage, that divers of the criticks themselves will chuse rather to absolve my writings, than condemn your judgment; and that at least the devout, to whom your practice has afforded so many other examples, will be scrupulous to be more severe to these papers, than a person, in whom, upon the score of her own style, severity were more justifiable than in most readers, (without excepting the eloquent ones) and will imitate her, in considering, that this book pretends to present them thoughts, rather than words; and in supporting, for the sake of the design, the manner, in which it is prosecuted.

AND certainly, my lady *R*'s approbation is a happiness, which divers sorts of considerations may render as advantageous as welcome to me. For if any of these thoughts do (which yet I can scarce hope) derive it from your justice, that great measure of esteem you do not only merit, but possess, may both assure them of a general one, and much contribute to procure it them. But if all of them owe your approbation (as I fear they do) to your partiality; since that must not be small, to be able to pervert such a judgment, this it self will prove an evidence of the blessing of your affection; which is a felicity, that I know you enough to value above all the praises I can miss of: since applause can make me happy but in other men's opinion, but your friendship can make me so in my own. Yet, apprehend not, sister, that I should here endeavour, by a solemn character of you, to justify what I have been saying;

saying; for, though to write a dedicatory epistle, without a panegyrick, be grown of late very unfashionable; yet since it is as much so, to take the praises wont to be profusely given in such letters for measures of any thing but the writer's wit, I must rather reserve the acknowledgments I owe your merit and your favours, to some occasion, where they may not be liable to pass for a tribute paid to custom, not a debt due to you, than draw a needless suspicion upon the sincerity of our friendship, by endeavouring to express my affection and esteem in a dedicatory letter; and by chusing to profess, upon an occasion where custom allows men to say what they do not think, so great and real a truth, as that of my being, far more upon the account of esteem and gratitude, than of nature it self,

My dearest Sister,

Your most affectionate,

and most faithful Servant,

R. B.

AN INTRODUCTORY PREFACE.

WHEN I consider the disadvantages with which the following trifles come abroad, in an age, that is not only so censorious, but so intelligent, as this of ours; neither the partiality of my friends, nor the favourable reception, that the publick has hitherto vouchsafed to what hath been presented it of mine, is able to give me a confidence, (though they almost create a hope) that these papers will meet with as kind an entertainment, as those of the same hand, that have preceded them. And yet, without being wanting to my self, I cannot but add, that by the help of their suggestions, who have urged the publication of these thoughts, I am not unfurnished with (at least) tolerable excuses for the things, that seem likely to stand in need of any.

I SHALL not much wonder to find it said, that the book is, in general, far short of being an exact and finished piece. For perhaps few readers will be more of that mind, than the author is. But by way of apology, it may be represented, that most of the following papers being written for my own private amusement, a good deal of negligence in them may appear as pardonable, as a careless dress, when a man intends not, nor expects, to go out of his study, or let himself be seen. And that which I now publish, being designed, not to satisfy the criticks, but to gratify the devout, I hope it will be thought a venial crime, if in some of these meditations I have not aimed to express eloquence, but only to cherish piety. I say in some, because there may be others (where a different style was thought fitter) in whose favour I would produce such suffrages, as would not be slighted, if I were concerned to do any more for those papers, than excuse them.

AND perhaps they, that shall take the pains to try their skill in making meditations indifferently upon the occurrences that shall happen, and wander no farther from the circumstances of their themes, nor lard them any more with sentences and other passages borrowed from the fathers, or the poets, than in most of the following papers I have done; will not find the task so easy, but that they will think it reason-
able

able to be mild in their censures, and will discern, that in such composures, some un-accurateness is so hard to be avoided, that it should not be hard to be forgiven.

I KNOW the want of uniformity in the style of the ensuing reflections may speciously enough be censured. For, not to mention, that some of them are very long, and others very short; it will be said, that some are written in a very neglected, and others even in a luxuriant strain; and there may (perchance) appear betwixt some of them as great an inequality as can easily be found betwixt composures, that are none of them excellent. Besides that the incoherence of the subjects, together with the differing ways wherein they are handled, may make them look so little of kin to one another, as scarce to appear the productions of the same pen. But this uneven way of writing will possibly be rather pardoned than wondered at, by those, that shall be informed,

THAT the nature of this kind of composures requires not any other, than a loose and desultory way of writing.

THAT these reflections are very far from coming abroad in the order of time, wherein they were set down; but in that casual order, wherein, when I was engaged to tack them together, I was able to light on them among my loose and forgotten papers. Many of which being discovered to have been lost, when some of the rest were to be at the press; I was fain, for the compleating of the number, to insert here and there some of a much fresher date, among those that were made (as some know, who then read them) sixteen or seventeen years ago, when my style could hardly be other than differing enough from what it now is.

AND lastly, that the differing natures of several subjects required, that the reflections on some of them should be far longer than others. And as my want of leisure, and sometimes of disposedness to write, induced me to make some of my considerations but short; so I thought fit to let them pass for their sakes, to whom, for want of time or skill, the brevity of those may make them the fitter, and the more recommend them.

BESIDES what has been alledged against the style, I know it may be objected, that in some of the meditations the subjects are very mean, and trivial; and that such themes are not worthy the being descanted on. And indeed, if I aimed at the writer's advantage, more than the reader's, I could easily have left them out, and have substituted in their places, some others, that lie by me, less liable to contempt. But I confess, I did not think my self obliged to publish no meditations, but the least censurable ones that I had made; and divers of those intimated in the objection were purposely inserted, when I was prevailed with to bundle up these loose sticks into faggots. For then, designing this treatise for the benefit of the generality of devout readers, I thought it not amiss, amongst divers reflections, (such as most of the second, and of the fourth sections) more suited to those perusers that are either of the more intelligent sort, or good proficients already, to insert some few meditations, of a more familiar sort, and easier to be lighted on; to keep those from being discouraged from trying to make occasional reflections; who may chance to have either barrenner fancies, or more unpractised pens, than even I had then. And those (perhaps) who, without such easily imitable examples, would not be invited to make occasional meditations, may, by the practice of composing them, grow such proficients in the art, as to surpass some, that despise such humble beginnings.

BUT as I send abroad these papers without the author's name, that I may have the greater opportunity to hear other men's opinions of them, and the less temptation to wave the complying with those that shall seem reasonable; so if I shall find, that such readers, as I esteem competent judges in an affair of this nature, shall think, that
those

those reflections, wherein I have complied with the weaker sort of perusers, may be better spared, than inserted; I can easily repair that fault in the next edition (if these trifles shall be thought worthy of another). In the mean time, I presume, that those devout readers, who may be concerned in this matter, will take it kindly, that I have, for their sakes, adventured to treat of subjects too mean and barren to furnish me with almost any thing considerable, save the opportunities of manifesting, how low I can stoop to gratify such persons.

I KNOW it is a new thing, that I have ventured to put some occasional reflections into dialogues. But the reader will be less startled at my deviating in this, and other things, from bishop *Hall's* way of writing occasional meditations, if I acknowledge, that not to prepossess or bias my fancy, I purposely (till of late) forbade my self the perusing of that eloquent prelate's devout reflections. Which intimation being premised, I shall subjoin, that when I wrote for my own divertisement, I sometimes took pleasure to imagine two or three of my friends to be present with me at the occasion, that set my thoughts on work, and to make them discourse, as I fancied persons, of their breeding and tempers, would talk to one another on such an occasion. And one of these, whom I call *Eusebius*, being a Doctor of divinity; two others (*Eugenius* and *Genorio*) being travellers and fine gentlemen; and the fourth, (whom I name *Lindamor*) being a learned youth, both well born and well bred; I was apt to think, that some of their conferences might be allowed to pass among the other papers; both because novelty, and variety, are wont to be not unwelcome things, and because this way of writing allows a scope for diversity of opinions, for debates, and for replies, which most commonly would be improper, where only a single speaker is introduced. Not to add, that possibly if this way of writing shall be liked and practised by some famed and happier pen, that were able to credit and improve it; it may afford useful patterns of an instructive and not unpleasant conversation: and such reflections, being of the nature of short and occasional essays, may afford men the opportunities of saying the handsomest things they know, on several subjects, without saying any thing else of them, or filling above a sheet, or perhaps a side of paper at a time. And the liberty, that this way of introducing speakers allows, brings with it a conveniency, which it is more easy for an intelligent reader to conjecture at, than it were discreet for the writer to mention expressly.

ANOTHER novelty will probably be taken notice of in the following papers, where the second and fourth sections, though by far the longest in the whole book, are entirely taken up; the former only by meditations on accidents relating to an ague that once afflicted me; and the latter by those, that occurred to some anglers by the river side. But for this matter, I presume, it will not be difficult to apologize. For having observed men to be inclinable, either openly to object, or at least tacitly to suspect, that in occasional meditations, that may hold true, which is (perchance not altogether undeservedly) said of epigrams, that in most of them the conceits were not suggested by the subjects, but subjects were pretended, to which the conceits might be accommodated; I thought, that to manifest, that (at least, some) writers of this kind of composures need not have recourse to the suspected artifice, the fittest way I could take was, by putting together, what the accidents of my ague, and of my angling journey, had suggested to me, to shew, that it is very possible for a person, that pretends not to a very pregnant fancy, to discourse by way of reflection upon the several circumstances, that shall happen to occur to his consideration, though one subject should require above fifteen differing meditations, and the other above twenty. Not to add, that it was rather weariness and design, than want of thoughts upon other passages.

passages relating to the same subjects, that kept me from increasing the number of those reflections.

As for the similitudes, though some would make me hope, that they will be at least excused; and though it were perhaps no great vanity for one, that does assiduously enough converse with the works of nature and the productions of art, to think he has the means of furnishing himself with pretty store and variety of comparisons: yet for all this, I am not willing to quit my pretensions to a share in the wonted effects of that common equity, which forbids to exact too accurate a likeness in the making of comparisons, which orators confess ought to be judged with indulgence, and without exacting a conformity in other attributes betwixt the things compared, provided there be a competent likeness in reference to the particular, wherein the collation or parallel is made.

AND if I have, on some occasions, prosecuted the resemblance through all the particularities, wherein the parallel could be made to hold, more fully and nicely than is usual in ordinary comparisons; and if in so doing I may have at any time a little strained the similitude, the better to accommodate it to my present theme, and design; I have this to represent, that to display resemblances to the full, and insist on their particular circumstances, is oftentimes no more than the nature of these compositions does allow, if not require; and that, on such occasions, to stretch the parallel as far as it can well be made to reach, is but a venial fault, which many readers are disposed not only to pardon, but to like. As if, in some cases, it fared with similitudes as with bows, which they though they may be bent so forcibly, as to be thereby broken or spoiled; yet by being strained somewhat more than ordinarily, they acquire a greater strength, and enable the arrow to pierce farther, and to make a smarter impression, than else it would.

THE protasis (as rhetoricians call the first part of a comparison) may in some of the following reflections appear to be too much amplified, and needlessly to lengthen the meditation. But not to urge, that sometimes the more conspicuous adjuncts of the subject were so mean and barren, that there was a kind of necessity to exaggerate, or to expatiate upon little circumstances to invite attention; the protasis, wherein we display and consider the minute particularities of the theme, being the ground-work of all the rest, and it being far more easy to say little, than much, with equal pertinency upon a subject; I thought it not amiss, to afford unpractised readers the most assistance of examples in such cases, wherein it is probable they will most need it; especially since he, that has accustomed himself to write copiously, may easily contract his discourse when he will, by omitting as many passages as he pleases; and it is far more difficult for a beginner to supply barrenness, than retrench superfluities. Which are not always such faults, but that I remember some great masters in the art of oratory have pronounced redundancy to be a good sign in a young writer, as taking it for a mark of a fruitful and exuberant fancy, that, in its productions, there is something to be cut off. So that if there should be found any luxuriant expressions in some of those thoughts, that were written down, when I had not yet attained my 19th or 20th year, when I might be allowed to write not always to employ, but sometimes to amuse my self; I may hope, that the same youth, that was my temptation to write them, may prove my excuse for having written them, as it may for leaving them unexpunged; that as I desire to invite as well young gentlemen as other readers, to pen occasional meditations, so I find, that some of the readers, I am willing to pleasure, do as little dislike that luxuriant way of writing now, as I did then: as youths and ladies oftentimes better relish must than wine.

I know too, that there may be found, in some of those protases, divers passages, and particularly some descriptions (that often make a great part of them) which to some readers will not seem noble and gaudy enough. But to such perusers it may be represented, that a suitableness to the theme, how mean soever it be, may very well, as a piece of decorum, be allowed to a writer, and in few cases more than in point of descriptions: and that these being but pictures drawn (with words instead of colours) for the imagination, the skilful will approve those most, that produce in the mind, not the finest ideas, but the likest; as a critick in limning will more prize the picture of an old meagre Sibyl, where the wrinkles and the fallow skin are drawn exactly to the life, than a dozen ordinary pictures of the spring, (which yet are wont to charm vulgar eyes) though the youthful face, which represents that florid season, have as gaudy colours upon the cheeks and lips, as imbellish the roses and lilies, which compose the chaplet that adorns the head.

AND possibly there will be found other readers (and those too skilled in rhetoric) that will accuse some other of our meditations, as being too elaborate, or too pompous, for the themes, whereunto they are accommodated. But having laid by a competent number of those lately mentioned reflections, wherein I aimed chiefly at inviting and assisting readers of meaner capacity; I confess, that in the other meditations, aiming either at my own divertisement, or the gratifying another sort of persons, I allowed my self to make choice of such applications of the objects I considered, as I thought every body would not so easily light on. And, provided the reflections were not strained, nor too far fetched, I thought it not amiss they should be somewhat surprizing; that I might by the way of handling the subjects I was to treat of, engage an attention, which otherwise I could scarce expect for such unpromising themes. I know, that if the judgment of some severe criticks were as infallible as themselves think it, the style of some of the following reflections would seem disproportionate to such mean and trifling subjects. I do not perhaps ignore what rhetoricians are wont to teach, of what they call the three differing characters of writing; I have read those discourses, that *Cornificius* proposes as the patterns of the sublime, the moderate, and the humble way of expressing one's self on differing occasions; and I have been taught, and willingly acknowledge, that all themes are not so well capable of that character, which they call sublime; and that, according to the nature and dignity of the subjects that one treats of, the manner of handling them ought to be varied. But if I were much concerned in this matter, I might reply, that notwithstanding all this, I know, that even the artists themselves do not so perfectly agree about the defining of these matters; and the grand rule about these characters being only, that the laws of decorum (or, as the French call it, *bien-seance*) be not violated, in the estimate of that decorum, I see no great reason to confine my self to the magisterial dictates of either ancient or scholastick writers. For, living in this age, and in this part of the world, where we are not like to have those for readers, that died before we were born, I see not why one may not judge of decorum by the examples and practices of those authors of our own times and countries, whose writings are generally esteemed by judicious men.

AND certainly, in the judging of what is decent on particular occasions, we must as well consider, who it is that is introduced as the speaker, as what it is he speaks of. And though it be improper to do what those have done, that have unadvisedly made shepherds and nymphs discourse like philosophers or doctors of divinity; yet when the writer either speaks himself, or introduces any, whom he represents as intelligent persons; they may be allowed, even about things ordinary and mean, to talk like themselves, and employ expressions that are neither mean, nor ordinary.

It nigrum
campis ag-
men.

As *Virgil*, in his admired *Georgicks*, does in some passages, where he treats of contemptible insects, speak of them in so noble and lofty a strain, that when he mentions multitudes of ants, one would think he were speaking of an army of Moors; and when he gives an account of bees, his expressions about their common-wealth would scarce misbecome the majesty of that of *Rome*. Such passages do, notwithstanding the great disparity of themes, make the style of his *Georgicks* as well noble (if not strictly heroick) as that of his *Æneids*; and when he writes of ants and flies, he does it in a strain worthy of the same pen, that so loftily describes the destruction of *Troy*, and the adventures of that hero, whom he would have to be (thought not immediately) the founder of *Rome*.

I WILL not say, that since there is a mode in language as well as in clothes, I see not, why the fashion, that now-a-days allows our gallants to wear fine laces upon canvass and buckram, might not warrant the tricking up of slight subjects, with the richer ornaments of language: nor will I examine, whether men may not except against the authority of some jejune writers, that taking upon them to prescribe the laws of style, make so many of their precepts negative, that one may suspect them indited not so much by skill, as envy; which makes such assuming law-givers mistake the impotence of a barren fancy for the skillfulness of a critical judgment, and (valuing only the ideas they think they can reach) condemn whatever they despair to imitate. And, from those, that would be thought to censure the moderns, but out of a veneration for the ancients, one might, methinks, reasonably expect but light censures for employing upon occasion that noble figure of rhetoric called hyperbole; since I should be loth to use it often, with no more reserve, than those great orators, *Tully* and *Isocrates*, have sometimes done before me. But a just debate of the rules of estimating the decency would take up so much room, as must make it improper for this place; where all I contend for is, that though when one treats of various subjects, somewhat differing styles are indeed to be accommodated to them; yet this to be so done, as still to preserve a certain dignity in expressions. So that a writer may be sometimes engaged by his subject to use a lofty style, but without ever being obliged to employ an abject one; though indeed in some cases he may be allowed to stoop below what he is bound to, and forbear soaring, as well as avoid creeping. Nor am I, for my own part, much concerned to insist here on the subject I just now declined to debate. For if I mis-remember not, *Cicero* himself, as well as some succeeding orators, allow in divers cases to shift characters, even in the same discourse, according to the differing particulars, that happen to fall under consideration; and some of them add this reason, that hence there will arise variety, which is wont to be a welcome thing. And to apply this to the occasional reflections, that may be concerned in this debate, I must desire the reader to take notice of these two things: the one, that tho' the thing it self, which sets a man's thoughts at work, may be but mean in other regards, yet that, which the reflector pitches upon to consider, may be of another nature; as though the glow-worm, which afforded me the IVth reflection of the Vth section, be but a small and contemptible insect, yet the light, which shines in his tail, and which makes the chief theme of the meditation, is a noble and heavenly quality, and might have justified the having many things said of it, for which the sublime character would have been the most proper. The other particular I meant to point at, is, that oftentimes, when the protasis, or former part of a reflection, is spent upon considering some mean and trivial subject, the apodosis, or reddition, contains such an application of what one was taking notice of in the subject, that the thing pointed at may be some important moral instruction, or perhaps some theological mystery; and consequently may require and justify another than the former humble style,

style, and admit all the quickness of expression and the richest ornaments, that belong to those two higher characters, which rhetoricians call the subtil, and the magnificent. But if I should now and then deviate from bounds, which, not being conspicuous, it is difficult never to swerve from, I have this peculiar apology to make for such aberrations; that writing for the most part of themes wholly new, and untreated of by others, I must needs want the assistance of examples to regulate or authorize my expressions; about which I need not be yet very solicitous, if I may trust a learned and applauded writer (whose censure I desired) that is both able to judge skilfully, and wont to judge freely.

THESE things I have the more carefully insisted on, because I would not have those ingenious persons, that may chance to cast their eyes on these papers, to be tempted by any imperfections of mine, to think otherwise of occasional meditations, than that though there be some, yet there are not very many, of their themes so low and contemptible, but they are capable of affording reflections of another nature to them, that are dextrous in making application of things. And I would not have such discouraged from hoping to find in many themes, that seem despicable at first sight, some hint or other, that may give those, that have wit or eloquence, opportunity enough to display those qualities. For as there is a great difference betwixt such writers, and common ones; so it is very material by what pens the subject is treated of; and extraordinary persons, in estimating what they are like to perform, must not only consider the unpromising nature of their subject, but the activity of their own fancy, and the pregnancy of their own wit. For though the stars cannot, the luminaries can, clothe the light and wandering vapours of the air with the colour of gold, and of roses; and the sun, by his piercing and improving beams, cannot only make diamonds sparkle, and rubies flame, but by his action upon an obscure cloud can make even that exhibit all those glorious and charming colours, for which we admire the rainbow.

AND, that the following papers may prove to such persons the lesser temptations to undervalue and mis-judge of this kind of composures; I am first to advertise the reader, that they are capable of so much greater variety, than the following treatise presents, that besides the vast multitudes of particulars unmentioned in it, that may be added under those heads, to which the ensuing meditations are referred, there are several distinct sorts or kinds of occasional thoughts, (such as those, that are made upon texts of scripture, or relate to less familiar points of divinity, or other learning, or contain historical applications, &c.) upon which I have, out of haste, and other reasons, purposely forborn (though not to write, yet) to publish reflections. And in the next place, I must here frankly acknowledge, that many of the ensuing reflections are so far from being the best, that even no better a pen than mine could make, that they are much inferior to divers, that I have already made; though (for allowable considerations) I have forborn to publish them. And I must confess, that I am more beholden to my occasional reflections, than they are to me. For, whereas they have furnished me with divers of the thoughts, which have been the favourablest entertained by the readers of my other books of devotion; I did much impoverish these papers, that professedly contain my occasional reflections, by not only leaving, but taking out of them several things, which were the most likely to have recommended them; that I might accommodate other writings, for which I had a greater kindness or concern.

As for the *Discourse of Occasional Reflections*, all that I shall say of it, is, that considering how early I attempted that subject, and that I was fain to repair, as well as I could, the unseasonable mis of divers papers belonging to it, when I dispatched it to

the press; considering these things (I say) I despair not, but that it will be thought, that I have not said nothing in favour of a subject that hitherto had so little said to recommend it, that even the eloquent Bishop *Hall**, employing but some lines, not pages, upon the praise and utility of it, (which he mentions but in very general terms) left me to find out, by my own thoughts and experience, the various considerations, by which I have endeavoured to display the usefulness of the way of thinking I would invite to. Which I have further manifested, by applying to that scope divers passages of scripture, (which the reader must therefore not wonder, if he do not now meet with) as texts, that either by way of example, or upon other accounts, belong to what I have written about the method of making occasional reflections.

It is true, the discourse may seem somewhat incomplete, because of the omission of this way, that is more than once mentioned in it.

BUT though the loose papers, wherein that method, and divers examples of it, are set down, were lying by me, when I tacked up those that now come abroad; yet my occasions easily prevailed with me to continue to suppress them. For though I did not much scruple to comply with my haste, and avocations, by forbearing to swell a book, whose bulk already much exceeded my intention; because that, as the papers, that now appear, were extorted from me, so I confess, that I was not fond of exposing those, that I had an expedient to keep back: but that I think it very fit to observe, first, whether the reception, that the following meditations will find, will make me and others think it worth while to have the ways published, that I was wont to use in making them.

I HAD almost forgot to intimate, that some urgent avocations having obliged me to send the following treatise to the press without reading it over my self, I now find, that my haste will make me need an apology to those readers, that expect to have the passages and phrases of scripture printed in a discriminating letter, and quoted in the margin. For though in books of positive, or of controversial divinity, I confess I have often observed a margin, stuffed with a multitude of citations, to contain divers so unconcluding, if not impertinent, that the number does better shew the author's memory than his judgment; yet in books of devotion, I am not much averse from complying with the generality of readers, who expect to be informed by the margin, where they may find those stories and expressions, which their being borrowed from an inspired book, make more operative and emphatical. But I must on this occasion further intimate, that as to those citations of passages of scripture, wherein I may seem to have mis-recited the words of the text; though as to some of them, that were set down when I had not a Bible or concordance at hand, my memory may have deceived me as to the words (which is no more than has often happened to the fathers themselves in the like case, and is a venial fault, where dogmatical or polemical divinity are not concerned) yet oftentimes my variations from the English version were made on purpose. For having had the curiosity to get my self instructed, as well by Jews as Christians, in the eastern tongues, (especially in the Hebrew) I thought I need not strictly confine my self to the words of our translators, whenever I could render the meaning of a text in such terms as to me seemed proper or expressive; or, without injuring the sense of the Hebrew or the Greek, could better accommodate my present purpose.

Now whereas some may think, that in this preface I employ excuses, that seem (some of them) not to agree with one another; I desire it may be considered, that the

* In the latter part of his *proëme*, whereof the whole amounts not to one page of this preface.

meditations they relate to, being not only written upon differing subjects, but (which is more) designed for very differing uses (some of those discourses being intended to invite the more unskilful, and encourage the more despondent sort of readers, and others, to entertain proficient) it was but requisite, that I should, by every differing (and, perchance, seemingly repugnant) considerations, give an account of such differing ways of writing them, as such distant subjects, and my scope, required.

BUT what if it should fare with me now, as it has done on other occasions, on which my friends have accused me, of framing more objections against my self, than were afterwards made against me by my readers? I dare not say it is impossible, but that this may prove the case. But if it do so, I shall not yet think my self to have altogether missed my aim in what I have hitherto represented. For I have mentioned the more particulars, and discoursed the more largely of them, that if they prove not needful apologies for my reflections, they may prove useful considerations for those, whom I would invite to exercise their pens in some such way of writing; divers of whom will probably be encouraged to venture upon making such compositions, when they find excuses for divers of those things, that are the most likely to be thought to blemish such essays, (or dishearten beginners from attempting them) to be drawn up already to their hands. But as for my own particular, if I could make none of the apologies now insisted on for the imperfections imputable to this treatise; yet I should not be destitute of a very just excuse for the publication of it. For divers devout persons, that had more partiality for these writings, and less tenderness of my reputation, than I could have wished, having long solicited the publication of those they had in their hands, were at length so resolved to effect it, that, in spite of the promises I at length made them to comply with their desires, when some other writings I was then about should be dispatched; I was fain to make use of a legal artifice, to hinder for a while at the Stationers hall the publication of divers papers, that I had not so much as read over.

BUT I confess I take notice of these passages, rather to excuse those imperfections, which haste may have occasioned in these immature productions, than to apologize for writing on such a subject. For so many advantages, that may accrue to a devout and skilful person, by assiduously making of occasional meditations, have been displayed in the discourse, that is premised to those that follow; that I hope the former part of this book will sufficiently apologize for my having written the latter; especially if to the other particulars proposed in the newly named discourse, as things fit to recommend that kind of thoughts, I here be allowed to add, that a man's devotion may not alone be cherished by occasional meditations, upon the account of those, which every private Christian makes for himself, but by the help also of those, which he finds made by others, or intends for them. For not only whilst pious reflections are making, they are proper to instruct the mind, and warm the affections; but the objects, upon which such meditations have been made already, either by our selves or others, do revive the memory of those good thoughts that were suggested by them. So that when diligence and proficiency in the practice of our Meleteticks shall have supplied us with religious, and handsome reflections, upon the most obvious works of nature, and the most familiar occurrences of human life, devout persons will have the advantage to live almost surrounded either with instructors, or remembrancers. And when they want skill, or are indisposed to extract spiritual things out of earthly ones, they may, without racking their invention, be furnished with good thoughts, upon many objects, by their memory. For (as I elsewhere more fully declare) those truths and notions, that are dressed up in apt similitudes, pertinently applied, are wont to make durable impressions on that faculty; inasmuch that though I am far from pretending

any

Would we
but keep
our whole-
some notions
together,
mankind
would be too
rich.
Bp. Hall in
his Proöme.

any of the reflections to be met with in the following treatise, to be made of that nature; yet such as they are, divers considerable persons of differing ages and sexes have been pleased to say (which is an advantage may richly recompense more trouble than those writings cost me) that they scarce ever see such or such particular things, on which I have written reflections, without remembering both those thoughts, and their author. So that they, who have so easily attainable things, as happier pens than mine, in setting down occasional meditations, may have the satisfaction of making almost the whole world a great *Conclave Mnemonicum**, and a well furnished *Promptuary*, for the service of piety and virtue, and may almost under every creature and occurrence lay an ambuscade against sin and idleness.

NOR is this indirect way of instructing men, unlawful for a Christian, or unworthy of him. For in the spiritual warfare, where our adversary is the old serpent, stratagems are as lawful as expedient; and he that gets the victory, whether or no he wins reputation by the manner, is sure to obtain (a greater recompense) glory, by the success. A teacher is not obliged to imitate *Alexander*, who, upon a disputable punctilio of gallantry, that was neither wise nor charitable, refused to steal a victory. For the prophet *Nathan* scrupled not to deceive *David*, that he might reclaim him, and surprize him into a confession of the criminality of his fault. And the Apostles being termed by their master, *fishers of men*, were warranted to make use of baits, as well as hooks and nets. And our Saviour himself, by the parable of the wicked husbandman, that usurped the vine, drew the Pharisees to an acknowledgment, which they started from as soon as they perceived what they had done. And the same divine teacher did so frequently imploy fictions to teach truths, that to condemn figurative and indirect ways of conveying even serious and sacred matters, is to forget, how often Christ himself made use of parables. And I am the less troubled to see some thoughts of mine, which, though unpolished, have a natural tendency to inveigle men (if I may so speak) into piety and virtue, thrust abroad into the world; not only because I see no reason to despair, that even as to the most obnoxious of these meditations, the examples they afford may make them useful, when the things they contain do not make them considerable and equitable, readers will rather pity, than admire to find, that an author does not soar, whilst he is clogged or depressed by the meanness of his subject. But because some experience seems to promise, that their novelty and variety will procure the book in general a favourable entertainment; and, indeed, if I had written in a more usual or a more solemn way, I should, perchance, have had no readers but divines, or humanists, or devout persons, or despisers of the world, or (in a word) the masters, or lovers of that one kind of learning, to which my subject did belong: but treating, as I do, of whatever chanced to come in my way, and consequently of many very differing and unusual things, curiosity will probably invite both the learned and the devout; both gentlemen and ladies; and, in a word, inquisitive persons of several kinds and conditions, to cast their eyes upon these reflections; which, by their variety and shortness, will have this advantage, towards the making them entertained with patience, that scarce any of them will give him, that peruses them, above half an hour's exercise of it.

AND as I thought it not any fault to have a regard to what was like to please a good part of the readers I wrote for, (though it would not else perhaps have pleased me, any more than it will the nicer palates of the criticks) so if these trifles chance to meet with half so kind a reception from the publick, as they have had

* So they call a certain room, artificially furnished with pictures, or other images of things, whereby to help the memory.

from particular persons, I shall not, perhaps, want the consolation, which may be derived from the judgment of a great master of wit, who scrupled not to affirm, that he had rather his entertainments should please the guests, than the cooks. Though they, that would compleat the good fortune of these papers, may do it more effectually, by addicting themselves (as considerable persons have been of late induced to do) to write occasional reflections (how excellent soever they may prove) than by being kind to these; since having written them, not to get reputation, but company, I cannot but be unwilling to travel alone; and had rather be out-gone than not at all followed, and surpassed than not imitated.

A

D I S C O U R S E

T O U C H I N G

OCCASIONAL MEDITATIONS.

S E C T. I.

C H A P. I.

THE way of thinking, whose productions begin to be known by the name of Occasional Meditations, is, if rightly practised, so advantageous, and so delightful, that it is pity the greatest part, even of serious and devout persons, should be so unacquainted with it: and therefore, dear sister, your desire to bring this way of meditation into request with some of our friends is that, which I cannot disapprove. But I am so far from having the vanity to think, that the trifles of this kind, your commands make me trouble you with, would recommend occasional reflections to those, whose eyes they were not meant for, that I think my self obliged to premise something touching the usefulness of this way of meditating, lest the careless and unpolished instances you will, I fear, meet with, among those I now present you, should disparage and bring a prejudice upon composures of this kind in general: wherefore, judging it requisite, to premise something touching this way of thinking, I shall forthwith apply my self to that task. And I should judge it a very natural distribution to divide the following discourse into two parts; the first of which should contain some invitations to the cultivating this sort of meditations, and the latter should offer something by way of method, towards the better framing of them. But lest I should at this time be hindered from treating of each of them distinctly, I will at present omit that division, and endeavour in recompense so to deliver the motives I am to propose, that the first part of the discourse may not appear maimed, though it be unattended by the second; and yet the particulars that might compose the second, may (if it prove convenient to mention them at this time) be commodiously enough inserted in opportune places of the first.

OF

Of inducements to this exercise, I might perhaps name many; but, for order's sake, I shall comprize them in the ensuing five; the first whereof will take up the present section, and the remaining four, as many others.

C H A P. II.

AND first, the way of meditating, I would recommend, conduces to keep the soul from idleness, and employments worse than idleness; for while a man's thoughts are busied about the present subjects of his reflections, our ghostly adversary is discouraged to attempt that soul, which he sees already taken up with something, that is at least innocent, if not good. If I had not elsewhere displayed the evil and danger of idleness, and represented it as a thing, which though we should admit not to be in it self a sin, yet may easily prove a greater mischief than a very great one, by at once tempting the tempter to tempt us, and exposing the empty soul, like an uninhabited place, to the next passion or temptation, that takes the opportunity to seize upon it: If (I say) I had not elsewhere discoursed at large against idleness, I might here represent it as so formidable an enemy, that it would appear alone a sufficient motive to welcome our way of meditation; that it banishes idleness. He that is versed in making reflections upon what occurs to him; he that (consequently) has the works of nature, and the actions of men, and almost every casualty, that falls under his notice, to set his thoughts on work, shall scarce want themes to employ them on: and he that can (as it were) make the world vocal, by furnishing every creature, and almost every occurrence, with a tongue to entertain him with, and can make the little accidents of his life, and the very flowers of his garden, read him lectures of ethicks or divinity; such a one, I say, shall scarce need to fly to the tavern, or a worse place to get a drawer, or gamester (perhaps no better qualified) to help him to get rid of his time: such a one will rather pity, than pursue those, who think it their privilege to spend their whole life in diversions from the main business of it; and out of an unskilful, and ill-governed self-love, are come to that pass, that they cannot endure to be with themselves. Such a one will not need to frequent the company of those gamesters, that are sure to lose that, which all their winnings will never be able to buy, or to redeem; and expose themselves coldly to as many casualties, as even war could threaten; and voluntarily tempt those passions it is the task of wisdom to decline, and a virtue to suppress; losing nothing but their time, without losing their patience too, and commonly a great part of that reverence and submission they owe to him, of whom the scripture tells us, that even *of lots themselves, the whole disposal is his*. Nor will he need, for want of knowing what to do when he is alone, to make it his almost daily employment, to make impertinent visits to unsanctified companies, where sometimes he may lose his good name, often his innocence, oftner his zeal, and always his time.

Prov. xvi.
33.

AND as the exercise, I would persuade, will help to keep us from idleness; so will it, to preserve us from harbouring evil thoughts, which there is no such way to keep out of the soul, as to keep her taken up with good ones; as husbandmen, to rid a piece of rank land of weeds, do often find it as effectual a course to sow it with good seed, as to cut them down, or burn them up. And indeed, the thoughts of many a person, are oftentimes so active, and restless, that something or other they must, and will perpetually be doing; and like unruly soldiers, if you have not a care to employ them well, they will employ themselves ill.

WHEREFORE, when a man hath once rendered this way of thinking familiar, sometimes the subject of his meditation will lead him to thoughts, and excite affections, full of serenity and joy, like those fair mornings, where the cloudless beams, and

cherishing

cherishing warmth of the sun, inviting the lark to aspire towards heaven, make her at once mount and sing; and when the mind is raised to such a welcome and elevated state, to listen to an ordinary temptation, a man must forego his pleasure, as well as violate his duty, and in the difference betwixt the employment that busies him, and that whereto he is solicited to stoop, he will easily discern, that his innocence will not be the only thing, that he would lose by so disadvantageous a change; and sometimes too, whether or no the employment, that busies his thoughts, happen to be so delightful, it will however appear to be so considerable, that it will seasonably furnish him with that excellent answer of *Nehemiah* to those, that would have diverted him from building of the temple, to come to a treaty with them, *I am doing a great work*, (and such indeed is the serving God, and the improving the mind, whether we consider its importance, or its difficulty) *so that I cannot come down: why should the work cease, whilst I leave it, and come down to you?* Which last expression suits very well with the present case; since, when a pious soul is once got upon the wing of contemplation, she must descend and stoop to exchange her converse with heavenly objects, for one with earthly vanities; and much more must she debase and degrade herself, if the things she is tempted to, be lusts, which she will thence clearly discern, to be as low as the hell they belong to, and deserve.

Nehem.
vi. 3.

AND as these objects will afford employment enough to our reflector, so will the wholesome instructions they will suggest, incline him to shun those ways of wasting his time, which they enable him easily to avoid. For I have observed this difference, betwixt ghostly dangers, and ordinary ones, whereas in military hazards, those, that are the most forward to thrust themselves into dangers, are commonly the best able to surmount them; they, on the contrary, are wont to be the most fearful of temptations, that are the most resolved, and best qualified to resist them.

C H A P. III.

NOR will the Meleteticks (or way, and kind of meditation) I would persuade, keep men alone from such gross and notorious idleness; they may be asked the question, proposed by the householder in the gospel, *Why sit ye here all the day idle?* But this way of thinking may in part keep men from the loss of such smaller parcels of time, as though a meer moralist would perhaps censure the neglect of them in others, yet a devout person would condemn it in himself; for betwixt the more stated employments, and important occurrences of human life, there usually happen to be interposed certain intervals of time, which, though they are wont to be neglected, as being singly, or within the compass of one day, inconsiderable; yet in a man's whole life, they may amount to no contemptible portion of it. Now these uncertain parentheses, (if I may so call them) or interludes, that happen to come between the more solemn passages (whether businesses, or recreations) of human life, are wont to be lost by most men, for want of a value for them, and even by good men, for want of skill to preserve them: for though they do not properly despise them, yet they neglect, or lose them, for want of knowing how to rescue them, or what to do with them. But as though grains of sand and ashes be a part, but of a despicable smallness, and very easy, and liable to be scattered, and blown away; yet the skilful artificer, by a vehement fire, brings numbers of these to afford him that noble substance, glass, by whose help we may both see our selves, and our blemishes, lively represented, (as in looking-glasses) and discern celestial objects, (as with telescopes) and with the sun-beams, kindle disposed materials (as with burning glasses): so when these little fragments, or parcels of time, which, if not carefully looked to, would be dissipated, and lost, come to be managed

Matth. xx.
6.

by a skilful contemplator, and to be improved by the celestial fire of devotion, they may be so ordered, as to afford us both looking-glasses to dress our souls by, and perspectives to discover heavenly wonders, and incentives to inflame our hearts with charity and zeal. And since goldsmiths and refiners are wont all the year long carefully to save the very sweepings of their shops, because they may contain in them some filings, or dust of those richer metals, gold and silver; I see not why a Christian may not be careful, not to lose the fragments and lesser intervals of a thing incomparably more precious than any metal, time: especially, when the improvement of them, by our Meleteticks, may not only redeem so many portions of our life, but turn them to pious uses, and particularly to the great advantage of devotion.

AND indeed, the affairs and customs of the world, the employments of our particular callings, the allowable recreations, that health, or weariness requires, and the multitude of unforeseen, and scarce evitable avocations, that are wont to share our time among them, leave us so little of it, to employ in the set and solemn exercises of devotion, and make those so unfrequent, that our hearts are in great danger of being, by the business, and pleasures, and hurry of the world, if not perverted from aspiring to, at least too long diverted from enjoying communion with God, and kept too much strangers to him; if in the long intervals of our more solemn exercises of devotion, we be not careful to lay hold on the short and transient opportunities of cherishing, and reviving that grace in us, and do not by the rises given us by the things that occur, take occasion to make frequent, though but short flights heavenwards, in extemporary reflections, serious soliloquies, piercing ejaculations, and other mental, either exercises, or expressions of devotion: by which means, we may make those very objects, and occasions, that would discourage, or at least distract our minds, elevate and animate them; as *Jonathan* made those very things, whereby his enemies, the Philistines, fought to intrap, or destroy him, encouragements to fight with them, and omens of his victory over them. And as scarce any time is so short, but that things so aile, and aspiring, as the flames of a devout soul, may take flight to heaven, (as *Nehemiah* could find time to dart up a successful prayer to the throne of grace, whilst he stood waiting behind the king of *Persia's* chair) so by these extemporary reflections, as well as by other mental acts of piety duly made, a devout soul may not only rescue these precious fragments of time, but procure eternity with them.

S E C T. II.

C H A P. I.

A SECOND inducement to the practice of making occasional meditations, is, that for an exercise of devotion, it is very delightful, and that upon fundry accounts.

FOR first, variety is a thing so pleasing to human nature, that there are many things, which it, either alone, or chiefly, recommends to us, and it is rarely seen, that we love the same things, very much, and very long; and of things that else would appear equally good, we usually think that the better, which happens to be another. Now, a person addicted to make occasional meditations may be supplied with subjects, whose variety is scarce imaginable: for the works of nature and of art are not the only objects, that often present themselves to our reflector's consideration; the revolutions of governments, the fates of kingdoms, the rise and ruin of favourites; and, on the other side, the most slight and trivial occurrences; and in short, all that he sees happen from the highest transactions, to the slightest circumstances, incident

to human affairs, may afford matter of contemplation to a person disposed to it. The mind of man is so comprehensive, and so active a faculty, that it can force its passage into those imaginary spaces, that are beyond the outermost part of the outermost heaven, and can in a moment return back, to consider the smallest circumstances of the meanest of human affairs; so that the thinking faculty, being equally fit, and disposed to reflect upon the works of God, and the actions of men, how unlikely is it, that it should want variety of subjects to be employed on, whilst the whole world makes but a part of its object; and the several productions of nature and art, of the providence of God, and the will of man, may be so many ways considered, and so variously compounded, that they may well be supposed capable of affording occasions to notions and reflections far more numberless than themselves; so that the most vigorous, and the most active soul, is in less danger of wanting fresh game, than thoughts to pursue such endless variety of it.

BESIDES, whereas men are wont, for the most part, when they would study hard, to repair to their libraries, or to stationers shops; the occasional reflecter has his library always with him, and his books lying always open before him, and the world it self, and the actions of the men that live in it, and an almost infinite variety of other occurrences being capable of proving objects of his contemplation; he can turn his eyes no whither, where he may not perceive somewhat or other to suggest him a reflection.

BUT that, which may much indear such meditations, is, their surprizing even him, whose thoughts they are: For one of the chief accounts, upon which wit itself is delightful, is, in very many cases, the unexpectedness of the things that please us; that unexpectedness being the highest degree of novelty, which, as I freshly noted, does exceedingly gratify most men's minds. We need not in this case, as in most others, make an uneasy preparation to entertain our instructors; for our instructions are suddenly, and, as it were out of an ambuscade, shot into our mind from things, whence we never expected them, so that we receive the advantage of learning good lessons, without the trouble of going to school for them, which to many appears the greatest trouble, that is to be undergone, for the acquist of knowledge. But though these irradiations of light be oftentimes sudden, as that which we receive from flashes of lightning, yet it is not always upon the single account of this suddenness, that the instructions, presented us by occasional meditations, have an unexpectedness; for oftentimes, the subject, that is considered, appears not to be any thing at all of kin to the notion it suggests. And there are many of these reflections, whose titles, though they name the occasion of them, do so little assist, even an ingenious reader, to guess what they contain, that if you tell him what is treated of, he will scarce imagine, how such thoughts can be made to have a relation to such remote subjects; and the informations we receive from many creatures, and occurrences, are oftentimes extremely distant from what, one would conjecture to be the most obvious, and natural thoughts those themes are fitted to present us; though, when the circumstances are thoroughly examined, and considered, the informations appear proper enough. Thus, when a navigator suddenly spies an unknown vessel afar off, before he has hailed her, he can scarcely, if at all, conclude what he shall learn by her; and he may from a ship, that he finds perhaps upon some remoter coast of *Africa*, or the *Indies*, meet with informations concerning his own country, and affairs. And thus sometimes a little flower may point us to the sun, and by casting our eyes down to our feet, we may in the water see those stars, that shine in the firmament, or highest visible heaven.

C H A P. II.

AND lastly, the pleasantness of these meditations to him, that hath attained skill in making them, will, if he be not much mortified, be much increased by their being proofs, as well as effects, of skill. To be able to take up instructions in books, that are replenished with them, and where they are purposely and distinctly exhibited in the form of instructions, requires rather that a man be docile than ingenious: but to be able to collect moral and spiritual documents out of a book of hieroglyphicks, or from a landskip or a map, is more than every attentive considerer can do, and is that, which argues something of dexterousness and sagacity, that is not very ordinary. And so, from ethical or theological compofures, to take out lessons, that may improve the mind, is a thing much inferiour to the being able to do the like out of the book of nature, where most matters, that are not physical, if they seem not to be purposely veiled, are at least but darkly hinted. And methinks there is such a difference betwixt him, that but takes up instructions in books of morality and devotion, and him that by occasional reflections derives them from the book of nature, and the accidents he chances to take notice of, as there is betwixt an ant, that contributes nothing either to the production or improvement of the corn she lays up and feeds on, but only carries away that, which she finds ready formed into its little granary or repository; and the industrious bee, who, without stealing from flowers any thing that can prejudice them, does not only gather, but improve and transform her food, and live on that, which otherwise would be useless; and besides, not only has the pleasure to gather its food from flowers, and from variety of them, but lives upon honey, an aliment, that is as sweet and delicious as nutritive. It was doubtless a very great pleasure to *Aesop*, that by his ingenious fictions he could, in a manner, lend reason and speech to lions, foxes, crows, and other animals, to whom nature had denied both; and I know not why it should be less delightful, by occasional reflections, to turn not only birds and beasts, but all kinds of creatures in the world, as well mute and inanimate, as irrational, not only into teachers of ethicks, but oftentimes into doctors of divinity, and by compelling senseless creatures to reveal truths to us, that they were never acquainted with themselves, perform really something like that, which was but pretended by the ancient augurs and other diviners the heathen world admired; who took upon them, by the casual flights of birds, and the inspection of the intrails of beasts, to learn the will of heaven. It is a piece of skill, for which mathematicians have been deservedly admired, and which is little less pleasing to those that have it, than wonderful to those that have it not, that as if artists were able to prescribe to the sun and moon, and the rest of the luminous globes of heaven, both their pace and their stages, they can make that inexhausted fountain of light, at so immense a distance, by the shadow of a little gnomon, fitly placed, give us an exact account of all the journeys he performs in the zodiack: but perhaps, it is neither a less noble nor a less delightful piece of skill, to be able, by an innocent kind of necromancy, to consult the dead, and conjure up worm-eaten carcasses out of their mossy graves, without fearing to hear from them such dismal discourses, as *Saul* had from dead *Samuel*, and to make, not the stars only, but all the creatures of nature, and the various occurrences that can fall under our notice, conspire to enrich us with instructions they never meant us; since the motion of the celestial lights are known, certain, and invariable; but these particulars are neither to be defined by number, nor limited by rules. Not to say, that this secret does as much excel that other, which recommends astronomy, as wisdom does science, and is as much the more useful.

useful of the two, as to know how to pass away our time is more profitable, than to know how our time passes away.

BUT there is a fourth particular, which, though somewhat less directly than the three I have already discoursed of, may be reduced to the pleasantness of occasional meditations; and it is, that whereas our innate self-love is wont to make any thing, that minds us of our faults, exceedingly uneasy and unwelcome; in the discoveries, that, by this way of thinking, are made us of what is amiss, the uneasiness is very much allayed, and the pill very well gilt. For there are two main things, that conduce to the sweetning of reproofs, and to keep men from being offended at them; the one is, when they come from a person, whom we love, and whom we believe to love us, and to have no other design in displeasing us than that of serving us: and the other is, that the discovery, that is made us of our faults, be sweetned by acknowledgments of our having qualities of a commendable nature, whence wise reprovers usually mingle, and, as it were, brew their reprehensions with praises. Now, both these pleasing vehicles, if I may so call them, and correctives of reproofs, concur in those we meet with in making occasional reflections. For, in these cases, being our own instructors, and our own consciences being the makers of the application, we cannot suspect the reprehensions to come from persons, that either mistake us, or are partial against us; and that truth, which a man's conscience applies to him, being found out by the sagacity of his own understanding, extracting from objects that, which every considerer would not have picked out thence; it may very often happen, that the same reflection will discover to a man his excellencies, as well as make him take notice of his faults: and that which makes him condemn the disorders of his affections, may argue, and thereby commend, the goodness of his parts.

C H A P. III.

I KNOW, it may be objected against the pleasantness of the mental exercise I have been speaking of, that to make occasional meditations is a work too difficult to be delightful.

IN answer to this, I might represent, that there are employments, wherein their being attended with somewhat of difficulty, is so far from deterring us, that it recommends them: as we see, that in hunting and hawking, the toil, that must be undergone, is so much an inearment of the recreation, of which it makes a great part, that when it happens, that we do not meet with difficulties enough, we create new ones; as when huntmen give the hare law, (as they speak) for fear of killing her, before they have almost killed their horses, and perhaps themselves, in following her. Yet I shall rather chuse to make a more direct answer, by observing, that the difficulties imagined in the practice I am treating of seem to arise, not so much from the nature of the thing it self, as from some prejudices and misapprehensions, that are entertained about it, especially the following two.

THE first is a needless scruple, which makes some fancy themselves obliged to confine their thoughts to the subject, that set them on work. And this dwelling long upon one theme is to many men a thing uneasy and tedious enough. But for my part, I see no necessity of such a strictness; and I have often observed the thoughts successfully to follow objects of a quite differing nature from those that were first started, from which perhaps, though more obstinately pursued, very little instruction or advantage would have been obtained. And it not unfrequently happens, that men trouble themselves in vain to make any profitable use of the considerations of those first objects, where the thoughts being licensed to expatiate themselves, they do often

at length pitch upon somewhat or other that is instructive, and at which, perhaps, they aimed at the very first, though they attained it by degrees, and pursued it by winding and untraced ways. As when we let a grey-hound loose in a warren, we confine him not to the first rabbit he makes after, since we see it frequently happens, that one sets him a running, and another proves his quarry. Nor do I conceive such a practice disagreeable to the nature of occasional meditations, nor to be excluded by their name; for that appellation may well enough be applied to those emergent thoughts, which fortuitous occasions did awaken or suggest to us; nor is it necessary, that our thoughts be always calculated for the subject that excited them, provided we thence took occasion to think; so that in some cases, the occasion is not so much the theme of the meditation, as the rise. For my part, I am so little scrupulous in this matter, that I would not confine occasional meditations to divinity it self, though that be a very comprehensive subject; but am ready to allow men's thoughts to expatiate much farther, and to make of the objects they contemplate not only a theological and a moral, but also a political, and oeconomic, or even a physical use. And I doubt, whether the groundless imagination, that occasional reflections ought to be confined to matters of devotion, or, at furthest, of morality, have not much helped to keep our Meleteticks so little cultivated, as hitherto they have been. And indeed there is so perfect an harmony, and so near a kindred, betwixt truths, that, in many cases, the one does either find out, or fairly hint or else illustrate or confirm, the other. And it is no wonder, that divers of them should belong to the same object, and be deduced from it. And if men were solicitous to apply the things they take notice of in occasional objects, to the discovery or illustration of oeconomic, political, or physical matters, it would probably bring such kind of thoughts more into request with several sorts of men, and possibly conduce to the improvement of those parts of knowledge themselves.

CHAP. IV.

THE other thing I proposed to mention, as that, which discourages many from the adding themselves to make occasional meditations, is a fancy, that to practise this kind of thinking, one is obliged to the trouble of writing down every occasional reflection, that employs his thoughts; and they conclude it far easier to forbear making any, than to write down all. But to do this, were to undertake a task no less unnecessary than tedious. Those meditations indeed, that have some excellency in them, that fits them to instruct others, should for that purpose be kept from perishing; and those that were not conceived without some extraordinary affection in a man's self, should be carefully pursued, as bellows to blow or rekindle devotion, by reminding us of the devout thoughts the like objects had excited in us. But for the rest of our occasional reflections, though they fill our heads, they need not employ our hands, as having performed all the service, that need be expected from them, within the mind already.

Nor would I have any man be discouraged from this way of thinking, that cannot express so much wit or eloquence in occasional meditations, as perhaps he may aspire to. For, besides that much subtilty of wit is not to be expected, or at least exacted, in this kind of composures, where we commonly make use of things rather out of haste than choice, as frequently being but the first thoughts we meet with, not the best we have; besides this, I say, that which ought most to endear this sort of reflections to a Christian, is rather that they cherish piety, than that they express wit, and help to make the man good, whether or no they make his style be thought so. It were injurious to nature to fancy, that the fig-tree derives no benefit from the rain

and fun, because they do not make it, like other trees, flourish with blossoms, more gaudy than necessary; though without previous buds it brings forth welcome fruits. Not to add, that the difficulty of framing occasional meditations need not be estimated by that, which we find when we first addict ourselves to the making of them; for practice will by degrees so much lessen that difficulty, that after a while we shall find, that occasional thoughts will need but small invitation to frequent those minds, where they meet with a kind entertainment. And though men should be reduced to purchase this habitude at the rate of a little difficulty, I doubt not but they will find the benefit of it, when gotten, richly to recompense the trouble of acquiring it. Nor will the practice, that must contribute to the attainment of a reasonable degree of skill in making them, be half so troublesome when those exercises but make up the habitude, as they will prove facile and delightful when they flow from it.

S E C T. III.

C H A P. I.

THE third grand advantage, that may be derived from the custom of making occasional meditations, is, that it conduces to the exercise and improvement of divers of the faculties of the mind. And this it may do upon several accounts.

I. **F**OR, in the first place, it accustoms a man to an attentive observation of the objects, wherewith he is conversant. Whereas there is scarce any thing, that may not prove the subject of an occasional meditation; so the natural propensity we have to manage well the themes we undertake to handle, unperceivably engages us to pry into the several attributes and relations of the things we consider, to obtain the greater plenty of particulars, for the making up of the more full and compleat parallel betwixt the things, whose resemblances we would set forth. By which means a man often comes to discover a multitude of particulars, even in obvious things, which, without such an engagement to attention, he would never have minded, and which common beholders take no notice of. And though it may seem, that the habit, produced by the practice of occasional meditating, should accustom a man to heed only such objects, as are like to suggest to him devout thoughts; yet, not to mention now, that I shall advertise you anon, that there is no necessity of confining occasional meditations to matters devout or theological, I shall only represent, that, since we know, not, before we have considered the particular objects that occur to us, which of them will, and which of them will not, afford us the subject of an occasional reflection, the mind will, after a while, be engaged to a general and habitual attention, relating to the objects, that present themselves to it. Besides that though we should at first apply our heedfulness to circumstances of only some few sorts of objects; yet the habit being once acquired, would easily reach to others than those that first occasioned it: as men, that by learning to sing anthems are come to have critical ears, will be able to judge, much better than they could before, of the resemblances and differences of tones in other songs, and will take notice of divers particularities in voices, which would not be heeded by an unpractised ear. And as we have made it appear, that the way of thinking, we would recommend, does very much dispose men to an attentive frame of mind; so, that such a frame or disposition is a great advantage in the whole course of a man's life, will not appear improbable to him, who duly considers, that since attention, like a magnifying glass, shews us, even in common objects, divers particularities, undiscerned by those who want that advantage, it must needs

needs make the things, he is conversant with, afford the considerer much more of instruction than they obtrude upon the ordinary regardless beholder; and, consequently, this exercise of the mind must prove a compendious way to experience, and make it attainable without grey-hairs; for that, we know, consists not in the multitude of years, but of observations, from numbers and variety of which it results. Nor is there any reason, why prudence should be peculiarly ascribed to the aged, except a supposition, that such persons, by having lived long in the world, have had the opportunity of many and various occurrences to ripen their judgment: so that if one man can by his attention make, as well he may in a small compass of time, as great a number of observations as less heedful persons are wont to do in a longer, I see not, why such a man's experience may not be equal to his that has lived longer; for it matters not much, whether a man make a competent number of observations, in much time or in little, provided he have made them well.

CHAP. II.

THE practice I would recommend, accustoms a man to make reflections upon the things he takes notice of, and so, by exercising, improves his reasoning faculty. For, as most men have much more strength and agility in the right hand than in the left; and, generally speaking, those limbs of the body that are most exercised, are stronger than the rest of the same kind; so the faculties of the mind are improved by exercise, and those, that we frequently employ, grow thereby the more vigorous and nimble. And, for my part, I have been often inclined to think, that the chief advantage, that the reasoning faculty derives from the institution received in logic-schools, comes not so much from the precepts themselves, which are pretended to make up an art of reasoning, as from the frequent exercises, that, by occasion of such precepts, the students are put upon. And, perhaps, if men were obliged to read the controversies of subtle wits, and to engage in frequent disputations, both premeditated and extemporary, it would add little less of readiness and acuteness to their wits, though they disputed of other matters than such as properly belong to logic, and were not before imbued with the precepts of that art: as we see, that the use of singing with those, that can sing well, does much improve one's voice, both as to strength and clearness, whatever the tunes or songs be, that are sung, and how little soever those, with whom one sings, make it their business to teach him the art of music.

BUT this is only conjecture; and whether it be true or no, yet this I am confident is so, that the bringing of a man to be a thinking and a reflecting person is to procure him so great an advantage, as though it were the only one may justly endear to him the custom of making occasional meditations; and he, that could bring this practice into the request it deserves, would do a greater piece of service, not only to the particular persons he persuades, but to mankind in general, than the greater part of good men themselves seem to be aware of. For though God having been pleased to make reason the chief part of our nature, among the various objects, that daily occur to us, it can scarce be, but that some or other will in a manner obtrude some notions even upon the unattentive; yet certainly, all that has been found worthy of mankind in mathematics, philosophy, and other kinds of learning, has been attained by thinking men, or by a frequent and regular practice of employing the thoughts. And lest it should be objected, that these various and elaborate effects of assiduous meditation were the productions only of philosophers, or other men of speculative heads; let us but consider, that though gallants and courtiers do seldom love to tire themselves with
 thinking,

thinking, and are as seldom fond of writing books, not to add, fit to write them; and though love be not the fruitfullest, that may be pitched on, yet that passion, and some particulars relating to it, frequently busying their thoughts, and being several ways considered by them, has been displayed and contrived even by such writers, as I have been just now mentioning, into those numerous plays, that daily employ the stage, and those voluminous romances, that are too often the only books, which make up the libraries of gallants, and fill the closets of ladies. He that most truly called himself the *Truth*, tells us, that the devil is not only a *lyar*, but the *father of lies*, that is, the great patron and promoter of falshood, and, as such, he studiously opposes all useful truths; not only those, for which we must be beholden to revelation, but those also, which may be attained by ratiocination, and the well-regulated exercise of our natural faculties; and he were much less an adversary and an old serpent than he is, if his enmity to God and man did not justly make him think, that scarce any thing is more his interest than solicitously to divert men from thinking, and discourage them in it, there being few things, whereby he could more effectually oppose at once both the glory of God, and the good of men. And sure, if so subtle an adversary did not think it very much his interest to be solicitous about this matter, it could not be, that men should chuse for a privilege, the laying aside that faculty of meditating, which is indeed so much their privilege, that, if experience did not convince the contrary, I could never suspect, that the non-employing of their thoughts could be their choice rather than their punishment; and that rational creatures, especially professing Christianity, should either keep idle, or confine to employments worse than idleness, so noble and improveable a faculty, that enables an ingenious man to pry into the inmost recesses of mysterious nature, and discover there so much of the wisdom, power, and goodness of the Author, as are most fit to give the discoverer a high and devout veneration for those excellencies. A faculty, whereby an inquisitive soul may expatiate itself through the whole immensity of the universe, and be her own teacher in a thousand cases, where the book is no less delightful than the lessons are instructive: A faculty (to conclude) by whose help the restless mind having dived to the lowermost parts of the earth, can thence in a trice take such a flight, that having traversed all the corporeal heavens, and scorned to suffer herself to be confined within the very limits of the world, she roves about in the ultra-mundane spaces, and considers how far they reach.

John viii.
44.

C H A P. III.

III. **B**ESIDES the two already mentioned advantages, which the intellectual part of the mind may derive from the practice of occasional reflections, I should not scruple to add a third, if there were not too just cause of apprehending, that my writings may discredit any thing, that comes proposed of that nature by no better a pen, and that the manner of what I am about to deliver may disparage the matter. But since, from the experience even of purblind and dim-sighted persons, good perspectives may be, not improperly, nor unsuccessfully, recommended, though their native and peculiar debility of sight keep them from being able to see as clear and as far through such glasses as other men can do, if themselves can, by the use of them, do far more than they could without them; I will adventure to speak of an improvement I cannot boast of, lest by suppressing the mention of an advantage, because I cannot make it, I should seem either vain, or envious, as well as dull. I shall then take notice, that the Meleteticks we are considering, may, where it finds a capable and disposed subject, much improve that nimble and acceptable faculty of the mind,

whereby some men have a readiness and subtilty in conceiving things, and a quickness and neatness in expressing them; all which the custom of speaking comprehends under the name of wit; which pleasing, and (if well managed) useful quality, the exercise I am discoursing of may three or four several ways promote.

For (first) the accustoming one's self to make extemporal reflections, and that upon all kind of occasions, does by degrees bring the mind to a readiness of conception, which keeps a man from being easily surprized by the subject he has occasion to consider, and enables him oftentimes to surprize his hearers; and that such a kind of surprize is one of the most endearing circumstances of the productions of wit, he must not have much considered the nature of them, that ignores.

NEXT, the same exercise inures a man to draw his conceptions from the very nature of the thing he speaks of; which, among those that can judge of wit, is held a far greater sign of it, than the saying things more specious and elaborate, that appear to be antienter than the occasion; as is usual in epigrams, and other solemn premeditated pieces of wit, where oftentimes the thoughts were not made for the themes, but before them: whereas the suddenness of a good occasional reflection, and its congruity to that which gave it rise, persuades the hearers, that the speaker's wit is of its own growth, and is rather suggested by the occasion, than barely applied to it.

A THIRD way, whereby our Meleteticks may conduce to wit, is, by bringing those, that use to write their thoughts, to what may be called a certain *suppleness of style*; for when a man treats of familiar, or of solemn subjects, he is so much assisted by the received phrases and manners of speaking, that are wont to be employed about them, that being seldom at a loss for convenient expressions, his wit is seldom distressed how to furnish him with words fit for his turn. But the subjects, that invite occasional reflections, are so various and uncommon, and oftentimes so odd, that, to accommodate one's discourse to them, the vulgar and received forms of speech will afford him but little assistance; and to come off any thing well, he must exercise his invention, and put it upon coining various and new expressions, to suit that variety of unfamiliar subjects, and of occasions, that the objects of his meditation will engage him to write of. And by this difficult exercise of his inventive faculty, he may by degrees so improve it, and, after a while, attain to so pliant a style, that scarce any thought will puzzle him to fit words to it, and he will be able to cut out expressions, and make them fit close to such subjects, as a person unaccustomed to such kind of composures would find it very difficult to write of, with any thing of propriety.

C H A P. IV.

IT remains, that I mention one way more, and that a considerable one, whereby the practice of occasional reflections may contribute to the improvement of wit; and that is, by supplying men with store and variety of good comparisons.

How great, and how acceptable, a part of wit that is, which has the advantage to be expressed by apt similitudes, every man's own experience, if he please to consult it, may, in some measure, inform him. And certainly, there is no one part of wit, that is so generally applicable to all kind of persons; for good comparisons serve equally to illustrate, and to persuade; the greatest wits disdain them not, and even ordinary wits are capable to understand them, and to be affected by them: and if a sermon, or a long discourse, be enriched with one apt comparison, what part soever else be forgotten, that will be sure to be remembered. And a but plausible argument, dressed

dressed up in fine similitudes, shall be more prevalent among the generality of men, than a demonstration proposed in a naked syllogism; and therefore, the ancient sages did so much chuse to imploy a figurative way of delivering their thoughts, that when they could not furnish themselves with resemblances fit for their turns, they would devise parables, and apologues, to recommend what they said to the attention and memory of those they would work upon. And those famous orators, who, though they lived in commonwealths, did, by their eloquence, exercise a more than monarchical government there, and who, by their enchanting tongues, ruled those warlike people, whose swords had made them masters of the world; those imperial wits, I say, whose oratory performed such wonders, performed them chiefly by the help of their happy comparisons, which alone contributed more to their success, than almost all the other persuasive figures of their triumphant rhetorick: lucky comparisons being indeed those parts of wit, that as well make the strongest impressions upon the mind, as they leave the deepest on the memory. Now, as the being furnished with apt comparisons does so very much conduce to the making a man's discourses and writings appear witty, so there is scarce any thing more fit and likely to supply a man with store and variety of comparisons, than the custom of making occasional meditations; for he, that uses himself to take notice of the properties and circumstances of most things that occur to him, and to reflect on many of them, and thereby observes the relations of things to one another, and consequently discerns, how the properties or circumstances of one may be accommodated, by way of resemblance or dissimilitude, to somewhat that relates to the other, will often find, besides those things which afford him his occasional reflection, divers others, which, though less fit for the meditation, that invited his taking notice of them, may be very fitly applicable to other subjects and purposes, and will easily furnish him with resemblances, wherewith he may, if he pleases, much increase the books of similitudes, already extant. And the comparisons, that may be this way lighted on, may sometimes prove strange, and unobvious enough, to be surprising even to himself, as well as to his auditors, or his readers.

C H A P. V.

BUT, besides those similitudes we may be furnished with by the things we observe, without turning them into occasional meditations, we may find in those very subjects, whereon we do make reflections, circumstances, that, though improper, or at least unnecessary, to be taken into the occasional meditation, may be very fitly accommodated to other things, and plentifully contribute to the store and variety of comparisons we lately mentioned. This must appear so much a truth, to any that is exercised in making occasional reflections, that I should perhaps forbear to illustrate it, by any particular example, but that this part of my discourse recalls into my mind some thoughts, that were suggested to me by one of the last occasions I had, to make reflections of this nature. I shall add then, that being all alone, and diverted a pretty while by a sudden storm of thunder, lightning, wind, and rain, from the employments I had designed my self to, I had the unwelcome leisure to make some reflections upon the rude objects, that obtruded themselves upon my observation.

AND the chief thing, that presented itself to my thoughts, was a resemblance betwixt prophane or atheistical wits, and the black clouds that then over-cast the sky: for, as those clouds are raised to an elevated station, and do afford flashes of light; so these irreligious wits are oftentimes conspicuous enough, and may bring forth notions, that are surprising, and instructive. But as the same clouds, whilst

Psal. cxix.
295.

they give us but their own momentary light, obscure (by darkning the sky) and hinder us, as much as they can, from receiving that of the sun, which reaches further, and is many other ways preferable to vanishing coruscations; so these wits, whilst they seem to enlighten those they dazzle, with their own new opinions, do really deprive them of the true heavenly light, that would else shine forth to them in the revealed word of God. And as the light, that we do receive from the clouds, may dazzle and astonish us, but is not sufficient for us to travel by; so the admired reasonings of these sophisters may surprize and amaze us, but will never prove sufficient to be, like the scripture, a constant *lamp unto our feet, and a light unto our paths*. And as the light afforded by such clouds is not only wont to be attended with affrighting thunder, and hurtful storms, but burns, and destroys, or at least scorches, and blacks, where it passes, and oftentimes falls upon churches, hospitals, colleges, and brings such frights and ruins wheresoever it comes, that it were a great deal better men wanted the light of such flashes, than that they should be exposed to such inconveniencies by them; so the insolent and irregular wits, I am speaking of, do not only make an unwelcome noise in the world, but do oftentimes so denigrate the reputation of them that oppose them, and bear so little respect even to things sacred, or useful to mankind, without sparing the church or seminaries of learning, if either come in their way, that they do far more mischiefs by their errors, or their practices, than the little instruction they give us is able to make amends for.

THIS, if I forget not, was the substance of the occasional meditation suggested to me by the storm; but, besides that, there are in this some particulars, which are not necessary to the meditation it self, and may be fitly enough accommodated, by way of comparisons, to other occasions. I remember, the same subject (the storm) had other circumstances in it, fit to afford similitudes applicable to other subjects, and some of them unobvious enough. For instance, it is not easy to find so illustrious a comparison, to set forth, how the most contrary qualities may proceed from the same subjects, as that which we may be supplied with, by considering, that from the same clouds we derive both light and darkness; and a noble comparison of contraries, conjoined in one subject, may be borrowed from the same clouds, which afford us lightning, and rain, shew that they contain in them two of the eminentest and seldomest consistent contraries of nature, fire and water. And another comparison may be derived from the differing productions of these clouds, to illustrate those things, which do at once both much good and much mischief, or sometimes the one, and sometimes the other: for the same clouds both produce the thunder, and the lightning, and thereby blast trees, kill men and beasts, fire houses, and ruin the noblest buildings, without sparing churches themselves; and, on the other side, plentifully afford us those refreshing and fertilizing showers, that correct the heat of the sultry air, and cure the barrenness of the parched earth. And one that is skilled in framing comparisons out of dissimilitudes, and exercised in the other ways of turning and winding of similes, may easily enough find, in the subject we have been considering, circumstances capable of being conveniently enough accommodated to more subjects and purposes, than I have leisure now to take notice of. And since, as the being able to find the latent resemblances betwixt things seemingly unlike, makes up a great part of what we are wont to call wit; so the being able to discern the unobvious disparities of things manifestly resembling is one of the chief things, that displays the faculty men call judgment. And since both these are very much assisted by the custom of making reflections, wherein we must take notice of the several properties, wherein things either are alike, or disagree; methinks it should not a little manifest

manifest the usefulness of our Meleteticks towards the improvement of men's parts, that they not only instruct the more serious faculty of the soul, but sharpen the more subtle.

C H A P. VI.

IV. **B**UT the practice I have all this while been recommending, does not only dispose us to attention, in observing the things that occur to us, and accustom us to reflect on them seriously, and express them fitly; but does also, though insensibly, suggest to us ways and methods, whereby to make the objects we consider informative to us.

For by example, analogy, or some of those other ways, which we may be invited, on another occasion, to insist on, we are, as it were, led by the hand to the discovery of divers useful notions, especially practical, which else we should not take any notice of. And indeed the world is the great book, not so much of nature, as of the God of nature, which we should find even crowded with instructive lessons, if we had but the skill, and would take the pains, to extract and pick them out. The creatures are the true Ægyptian hieroglyphicks, that under the rude forms of birds, and beasts, &c. conceal the mysterious secrets of knowledge, and of piety. And as chemists boast of their elixir, that it will turn the ignoblest metals into gold; so wisdom makes all objects, on which it operates, enrich the possessor with useful and precious thoughts. And since even the illiterate husbandman can, with the most abject dung it self, give a flourishing growth to the most useful grains, to medicinable herbs, and even to fragrant flowers; why may not a wise man, by the meanest creatures, and slightest object, give a considerable improvement to the noblest faculties of the soul, and the most lovely qualities of the mind?

BUT the particular method of deriving instruction from the subjects we consider will be more fit to be particularly insisted on, when we shall have more time, or some other opportunity, to treat of the manner of making occasional meditations; and shew, how they may be fetched from example, analogy, dissimilitude, ratiocination, and other topicks, which we must not now take any further notice of.

S E C T. IV.

C H A P. I.

HITHERTO we have considered the benefits, that may be afforded by the practice of occasional meditations to the *intellectual faculties*. We will now proceed to the advantages, that may accrue from the same practice to the *will and affections*; these advantages being not only the most valuable in themselves, but those, upon whose account I have been engaged in the present undertaking.

V. THE last therefore and greatest benefit I shall take notice of, in the practice II would invite you to, is, that it awakens good thoughts, and excites good motions in the will and affections. For since we have already manifested, that it is wont to suggest variety of notions to the meditator, and such as are usually accompanied with delight; this friendly property to devotion, which I now ascribe to our Meleteticks, is a very easy and genuine off-spring of the marriage of the two others: the beams of knowledge, acquired by such reflections, having in them, like those of the sun, not only light, but heat. And indeed it were somewhat strange, as well as sad, if a person disposed and accustomed to observe and consider, conversing with such instructive books as those of God's creatures and his providence, with an intention to take out
practical

practical lessons, should not find them. For amidst that rich variety of objects, that in differing manners proffer themselves to his consideration, and suggest to him a great diversity of reflections, it cannot reasonably be imagined, that he should not find subjects or circumstances, that are proper, either to afford him examples to imitate, or shew him the danger, or unhandfomeness, or inconvenience of something that he should avoid, or raise his thoughts and affections heaven-wards, or furnish him with some new practical consideration, or shew him some known truth in a varied and delightful dress, or (at least) recall some notions his frailty makes him need to be put in mind of, or, in a word, either refresh his memory, or otherwise cherish his devotion. Let us suppose a person, who being qualified and accustomed to reflect upon various objects that occur to him, mainly designs, in the exercise of that faculty, the warming of his affections, and the improvement of his piety; and we shall scarce doubt, but when he looks about him in the world, he will find it, what one of the fathers loftily styled it, παιδευτηρίου τῆς θεογνωσίας καὶ ψυχῶν λογικῶν διδασκαλίου, (a school for rational souls to learn the knowledge of God). There is scarce any thing, that nature has made, or that men do or suffer, though the theme seem never so low and slight, whence the devout reflector cannot take an occasion of an aspiring meditation: as in a hopeful morning the humble lark can, from the lowest furrow in the field, take a soaring flight towards heaven, and ascend thitherward with a melody, that delights both herself and her hearers. If such a person considers, how amongst such an admirable variety, and such odd antipathies of the numberless creatures that compose the universe, the constant observation of the laws of their nature makes them universally, and, as it were, unanimously, to conspire to make the author of it appear wonderful in it; he cannot but be willingly possessed with such an awful admiration of the matchless wisdom of their great disposer, as made the Psalmist cry out, upon a somewhat like occasion, * *How manifold are thy works, O Lord, how wisely hast thou made them all?* If he have occasion to consider the merciful dispensations of divine providence to the godly, or to take notice of the severe inflictions of divine justice on the wicked, he will find himself powerfully engaged to rely on the one, and to apprehend provoking the other. If he take notice, that the world is but our storehouse, and that multitudes of admirable creatures seem to have had a being given them, principally for the use of undeserving man; inasmuch that many of the beasts, and birds, and fishes, are but our caters for one another; he will burst out into mental, if not vocal, expressions of thankfulness and humiliation to the father of mercies, for so unmerited and ill returned a bounty, and will be apt to say with David, *What is man, that thou takest knowledge of him; or the son of man, that thou makest account of him?* And if he compare this munificence of God, in daily giving so many creatures, that never violate the laws of their nature, nor endeavour to disappoint him of his ends in creating them, for the necessities, nay, for the pleasures, of rebellious and unthankful man; he will resent an ingenuous shame, and a noble disdain, that that creature should be of all the least grateful, that has received the most benefits, and that he should of all others prove the most unruly, who alone has been endowed with reason to rule himself withal. If in a starry night he looks upon the firmament, and considers how many fixed stars there are, and how many thousand times more there might be without wanting room, the least of which astronomers teach us to be far bigger than the

Psal. civ.
24.

Psal. cxliv.
3.

* So Junius and Tremellius translate the place, *Quàm ampla sunt opera tua, O Jehova, quàm ea omnia sapienter fecisti?* and so the original will bear, if the Hebrew *Ma* be made applicable as well to the latter, as to the former part of the words.

whole earth, which yet, by the probablest computation, contains above ten thousand millions of cubick German leagues, (and consequently above threecore times as many *English* miles of solid measure) he will find abundant cause to exclaim with *David*, *When I consider the heavens, the work of thy hands, the moon and stars which thou hast ordained, what is man, that thou shouldst be mindful of him, or the son of man, that thou visitest him?* Psal. viii.
3, 4.

C H A P. II.

AND since our discourse has led us to the mention of a text, where the truly inspired poet (who, by his omitting to speak of the sun, seems to have composed this psalm in the night) makes the moon the chief subject of his meditation; it will not perhaps be amiss, if, on this occasion, we add a few short reflections on the same theme, and thereby confirm what we lately noted about the differing reflections and similitudes, which may be afforded by the same subject, as its several attributes may be differinglly considered.

If then, in the first place, when our contemplator takes notice of the greatest brightness of the moon, he remembers too, that it is when she is at the full, that she is subject to be eclipsed; it would put him in mind of the mutability of human things, and that oftentimes prosperity proves never the more secure for appearing the more full and resplendent.

NEXT, our reflector may find in the moon a lively emblem of a true minister of the gospel. For, as the moon communicates to the earth the light, and that only, which she receives from the sun; so the Apostles, and first preachers of Christianity, and (in their measure) their true successors, communicate to mankind the light, which themselves have received from the bright sun of righteousness. And the similitude may be advanced, by adding, that as the moon shines not on the earth, with any other beams than those she derives from that fountain of light, the sun; so the true preachers of the heavenly doctrine mingle not their own inventions, or human traditions, with that pure and sincere light of revelation they are employed to dispense: it being safest, and most desirable, for the church, that Christians should receive the bread of life, as the Jews are recorded to have received the material bread, in a passage of St. *Matthew's* gospel, where it is said, that Christ first brake, and gave to the disciples, the bread, which they afterwards, from him, distributed to the people; so that they might each of them, in a literal sense, imploy that expression of St. *Paul*, *I have received of the Lord, that which I delivered unto you.* Mat. xv. 36.
1 Cor. xi. 31.

AND as though the moon be destitute of native light, yet by virtue of that borrowed one, which she plentifully receives from the sun, she affords more to men than any of the stars, which, upon the score of their vast distance from the sun, are, by modern naturalists, supposed to shine by their own light; so those illiterate fishermen, whom the son of righteousness called, and made the light of the world, did, by virtue of the copious irradiations he vouchsafed them, diffuse far more light to mankind, than the greatest philosophers, that, being unassisted by divine revelation, had only their own native beams to shine with.

AND as oftentimes the same subject, but as variously considered, may afford both somewhat fit to be shunned, and somewhat fit to be imitated; so, in that, which we suppose our reflector now considering, he may easily discern the emblem of an ungrateful person. For as the moon, though she receive all the light that ennobles her from the sun, does yet, when she is admitted to the nearest conjunction with him, eclipse that bright planet, to which she owes all her splendor; so unthankful men abuse

abuse those very favours, that should endear to them their benefactors, to the prejudice of those that oblige them.

AND it is like, that our reflector may, by the way, take notice, that as what passes betwixt the moon and the sun, does thus afford him a simile, whereby to set forth ingratitude; so what passes betwixt the moon and the sea may supply him with an example of the contrary quality, and put him in mind, that a thankful man will be true and obsequious to his benefactor, though the person that obliged him have lost that prosperity, that before made him conspicuous, and attracted vulgar eyes; as the sea follows the course of the moon, not only when she shines upon it with her full light, but when at the change she can communicate little or no light to it.

To the two above-mentioned attributes, upon whose account the moon afforded a comparison for human prosperity, and another for preachers of the Gospel, we will now add, that she may afford us a similitude to set forth a liberal person by; for as the moon freely communicates to the earth the light she receives from the sun, so the bountiful person imparts to indigent men the largesses he receives from the exuberant goodness of God. And as to intellectual communications, the parallel will hold further, since as the moon enjoys not the less light, for her imparting so much to the earth; so in mental communications liberality does not impoverish, and those excellent gifts cease not to be possessed by being imparted. And it is very possible, (to add that upon the bye) that after the light of the moon has (according to what I lately noted) represented to our contemplator the qualifications of a preacher, it may also put him in mind of the duty of a hearer. For, as it were very foolish in us, and unthankful towards the father of lights, not to make use of the great light we receive from the sun by the moon, or not to acknowledge the moon to be a very useful creature, upon the score of that light, wherewith she shines upon the earth, though, in her, that light be destitute of heat; so it were unwise and ungrateful for hearers to refuse to acknowledge, or to be guided by, the conspicuous endowments of learning and eloquence, that God vouchsafes to great scholars, though they themselves were but illustrated, not warmed by the beams they reflect. But therefore, as oysters, and other shell-fish, are observed to thrive at the increase of the moon, though her light be unattended with heat, and though even when she is at full, she wants not her spots; so devout hearers will be careful to prosper proportionably to the instructions they receive even from those preachers, whose illuminations are unaccompanied with zeal and charity, and who, when they shine with the greatest lustre, are not free from their darkneses, as to some points, or from notorious blemishes.

AND as the moon may thus furnish our contemplator with similitudes, to set forth both a virtue and a vice of the mind, so may it supply him with an emblem of its condition; for as the light of the moon is sometimes increasing, and sometimes in the wane, and not only is sometimes totally eclipsed, but even when she is at the full, is never free from dark spots; so the mind of man, nay, even of a Christian, is but partly enlightened, and partly in the dark, and is sometimes more, and sometimes less, illustrated by the beams of heavenly light, and joy; and not alone now and then quite eclipsed by disconsolate desolations, but even when it receives the most light, and shines the brightest, knows but in part, and is in part blemished by its native darkneses, and imperfections. And these resemblances are not so appropriated to the mind of man, but that they might easily be shewn to be applicable to his condition, in point of outward prosperity, and adversity. And to these resemblances other reflections on the several adjuncts of the moon might be also added, together with

with several examples of this nature on other subjects, were it not, that I think myself to have spent time enough already upon a theme, that fell but incidentally under my consideration; and were it not also, that the reflections, which might here be annexed upon the attributes of other objects, may be more properly subjoined to what may be on another occasion presented to you, by way of illustration of some particulars, that belong to the fourth part of the precedent section, in which my haste, and some other reasons, made me content myself, to give some few general hints about such reflections, and an intimation of the topics, whence I am wont to fetch them.

C H A P. III.

AND having given you this advertisement, *en passant*, we may now proceed a little further, and add, that if we suppose our contemplator's thoughts to descend from heaven to earth, the far greater multitude and variety of objects, they will meet with here below, will suggest to them much more numerous reflections. But because so spacious a field for meditation as the whole earth would afford to us too vast a theme to be attempted on this occasion, we will confine our contemplator to his garden, or rather to any one of the trees of it, and take notice, not of all the meditations he might fetch thence, but only of four or five of the considerablest of those, that the viewing it may, as he walks by at several times, supply him with.

If then, in the spring of the year, our reflector sees the gardener pruning a fruit-tree, we may suppose him invited by that object, to reason thus within himself: Though one, that were a stranger to the art of gardening, would think, that that man is an enemy to this tree, and goes about to destroy it, since he falls upon and wounds it, with a sharp iron, and strikes off several of its youthful parts, as if he meant to cut it in pieces; yet he that knows, that the gardener's arm is not set on work by anger, but by skill, will not conclude, that he hates the tree he thus wounds, but that he has a mind to have it fruitful, and judges these harsh means the fittest to produce that desirable effect. And thus, whatever a man, unacquainted with the ways and designs of providence may surmise, when he sees the church not only exposed to the common afflictions of human societies, (for that is but like our tree's being exposed to be weather-beaten by winds, and rain) but distressed by such persecutions, as seem to be divine inflictions, that invite men to say of the body, what the prophet foretold should be said of the head, *We esteemed him stricken, smitten of God, and afflicted*: whatever, I say, a carnal, or a moral, man would be apt to imagine, upon sight of the church's distresses, the knowing Christian will not from thence infer, that God hates her, or that he has abandoned her; since it is he, that loved his church so well, as to give himself for it, who declares, that as many as he loves, he rebukes and chastens. And this is so fitly applicable also to particular believers, that the divine son of the great * *γεωργός* does not only give us cause to think, that afflictions do not suppose God's hate, but to hope that they may not always suppose man's guilt, but sometimes rather aim at his improvement; since they are the memorable words of our Saviour, speaking of his Father, *Every branch in me, that beareth not fruit, he taketh away, and every branch that beareth fruit, he purgeth it, that it may bring forth more fruit*. And it may somewhat illustrate the similitude to add, that the husbandman uses only to prune the trees of his garden, not those that grow wild in his woods; but though he oftner wound these, yet he wounds the other

Isaiah liii.

4.

John xv.

2.

John xv.

2.

* That is, Cultivator of the ground.

more fatally, imploying but the pruning hook to pare off the superfluous twigs, or at most, branches, of the one, whilst he lays the ax to the root of the other, to fell the tree it self.

BUT these are not the only thoughts, which the pruning of a fruit-tree may suggest to our reflector: for if he considers, that by cutting off several of the parts of the tree, and by nailing many of the rest to the wall, the gardener does not only secure the tree from being blown down, or torn, by the rudeness of boisterous winds, but makes it look well shaped; so the divine husbandman, (as we have lately seen God styled in the scripture) by the wise, and seasonable, though seemingly rigorous, and usually unwelcome, culture, he imployes upon those children of his, whom he afflicts, does not only protect them from several dangers, whereto, without those harsh restraints, they would be exposed; but as he makes them amends in point of safety for what he denies them in point of liberty, so he adorns them by wounding them; his kind and skilful strokes adding as much to the beauty of a Christian's mind, as they cut away from the superfluities of his fortune; for the pressures of affliction do give such smoothness and gloss to the soul, that bears them patiently and resignedly, that the heathen moralist ventured to say, that if there were any spectacle here below noble enough, and worthy to entertain the eyes of God, it was that of a good man, generously contending with ill fortune. And the hyperbole (though after this manner somewhat loosely expressed) will appear the less strange to him, that considers that *Job* had not only his patience, when it had been tried to the uttermost, crowned with a fortune double to that, which had been the fairest in the East; but before his constancy was tried near so far, received that much higher recompence of an honour never vouchsafed to mortals until then, when God himself did not only approve, but (if I may so speak with reverence) make his boast of, a man: *Hast thou considered* (says he to man's great enemy) *my servant Job, that there is none like him in the earth, a perfect, and an upright man, one that feareth God, and escheweth evil? and still he holdeth fast his integrity, although thou movedst me against him to destroy him without a cause.* Sure one may call him more than happy *Job*, since, if, as *David* tells us, the man is happy, whose sins God is pleased to cover; what may that man be accounted, whose graces he vouchsafes to proclaim?

Job ii. 3.

Pf. xxxii.
1.

CH A P. IV.

AND as the consideration of the pruning of trees, under the notion of *that which wounds them*, may afford our contemplator the reflections already pointed at; so the considering of the same action, under another notion, may lead him to reflections of another nature: for if he observes, that, in certain cases, gardeners oftentimes do not only prune away all the suckers, and many of the luxuriant sprigs, but cut off some of the branches themselves, provided they spare the master-boughs; and yet these amputations, though they take much from the tree, are designed to add to the fruit, as accordingly they are wont to do: if, I say, our reflector takes notice of this, it may easily supply him with an illustration of what he may have observed among some men, who, by afflictions, even in point of fortune, are brought to be far more charitable, than they would have been, if their peace and plenty had continued unimpaired. As, besides that *St. Paul*, speaking of the *Macedonian* churches, gives them this character, *That in a great trial of affliction, the abundance of their joy, and their deep poverty, abounded unto the riches of their liberality*; we have in *Zaccheus* a memorable instance to our present purpose, since, after his repentance had, by his own consent, cut off from his estate more than all that slander, oppression, and other unjust ways of getting, (which used to bring in but too great a part of a publican's)

2 Cor. viii.
2.

had added to it; he gave away more, out of the remainder of his estate, than every liberal man would have done out of the whole. His wealth, like a skilfully pruned tree, bore the more fruit to piety, for having had some parts of it cut away; he grew rich (in good works) by being despoiled, and his charity increased as much as his fortune was lessened.

IF, towards the end of the spring, our reflector see the ground under his tree strowed with the blossoms, that time and winds may have cast down thence, it is like it would furnish him with this consideration; That, as though the blossoms are in themselves great ornaments to a tree, and oftentimes both useful and pleasant things, yet to be seasonably deprived of them, is not a mischief to the tree that loses them; since, till the blossoms are gone, the fruit, which is a better and more lasting thing, and more principally intended by nature, cannot be had: so it will not always follow that because certain things are in their kind desirable, and therefore may be reckoned among goods, the loss or depravation of them must necessarily be an evil. And so, though a fair and healthy body may be looked upon as a blessing, yet it will not follow, that a *death* (as the Scripture speaks) either *in* or *for the Lord*, because it throws this flourishing body to the ground, and makes it rot there, must needs be a deplorable evil: since, as the blossoms falling off, is, according to the course of nature, necessarily previous to the formation, or, at least, the perfection, of the fruit; so the being deprived of this life is, according to God's ordination, a necessary antecedent to our being enriched with those more solid and durable blessings of perfect virtue and happiness.

ΟΙ ΙΗ ΚΥ-
ΕΙΣ ΑΠΟΘ-
ΝΩΣΚΟΥΤΕ.
REV. xiv.
13.

AND if, whilst our contemplator's tree is adorned with leaves, as well as blossoms, (as we often see several of the former come before all the latter are gone) he chance to take notice, how busy the bees are in sucking these, whilst they leave the others untouched, he may peradventure make this, or some such other reflection on it: That, though the leaves be not only ornaments of a tree, but productions, often useful to shade and shelter the fruit, and are of a more solid texture, and a more durable nature than the blossoms, which seem to be of a slighter make, and rather gawdy and delightful than lasting; yet it is not about the leaves, but the blossoms, that the industrious bee assiduously employs her time, as sucking from those gaudy productions of the tree store of that honey, which the leaves would not afford her.

THUS, though the books written about dogmatical and controversial points in divinity, may be in their kind valuable, and useful productions of skill in theology, and may seem more strong and substantial composures, and likely to retain their reputations longer, than books of devotion; yet it is of these, rather than those, that the devout Christian will be a solicitous peruser; since it is not from barren, though solid assertions or disputes, but from florid and pathetical books of devotion, which first allure the reader, and then affect him, that the devout soul extracts her honey, I mean, those celestial pleasures, that result from, as well as maintain, a free communion with God, which does at once both exercise her devotion, and recompense it, and afford her, as flowers do the bee, an aliment equally nutritive and delicious.

AND he may somewhat illustrate, as well as continue, the allusion further, by considering, that silk-worms, that live upon leaves, and bees, that feed on flowers and blossoms, do indeed both of them thrive upon their respective aliments, and are thereby enabled to present men with useful productions, but with this difference; that the subtle threads of silkworms serve principally to cloath others, whereas the honey, that is elaborated by the bee, does not only supply others with a healing and clean-

sing medicine in some distempers, but affords a great deal of pleasure to the bee herself: for thus, though as well the diligent studiers of speculative and polemical divinity, as the careful perusers of books of devotion, may be advantaged by what they study, yet this difference may be observed betwixt them, that the former may, by the discourses they read, be assisted to write others of the like nature, whereby their readers may be enabled to talk with more acuteness, and applause; but the latter may not only be assisted by making such composures, as they assiduously converse with, to contribute to the cleansing of men's consciences from dead works, and as well pacify the troubles of their minds, as heal the wounds, which schism or scandal may have given to the church; but do often, in the first place, feel themselves all the joys, and advantages, they would procure to others, and they happily find pious reflections, devout soliloquies, ardent ejaculations, and other mental entertainments of a religious soul, to be of a nature not only so sweet, but so improving, and so advantageous, that whilst many other laudable employments recommend us to the students of theology, these more especially recommend us to the Author of it, and in dear us to God himself.

If, when our fruit-tree has changed its white livery for a green, our considerer chance to take notice, how thick it is set with leaves, of which it had not one some months before, it may possibly put him in mind of the instability of their condition, that are undeservedly envied for a numerous train of such seeming friends, and gaudy attendants, as are so to the fortune, rather than the person: for, as in the sun-shiny months of summer, when the fair weather would keep the tree warm enough, without the help of leaves, it is wont to be covered with those verdant ornaments; but loses them all in winter, when it needs their shelter from the rigors of that cold season: so those, that during the sun-shine of prosperity, are beset with seeming friends, of which they had no need, find themselves left naked, and forsaken of them all, when adversity would make their company of some advantage. If our contemplator chance to observe, how his tree flourishes with verdant leaves, and gaudy blossoms, at that season of the year, when it is providing to bring forth fruit, it may put him in mind of the pleasedness and alacrity, with which a charitable person should set himself to the doing of good; and mind him, that as the God of nature loves a chearful giver, so the temper of a liberal person is pointed out by nature herself in a tree, which seems to triumph in all the ornaments it can put on, when it is about to exhaust the greatest part of its own stock of sap, to produce fruits, which only others are to eat.

If he take notice of the order, wherein it is usual for the leaves and blossoms to precede the fruit, it may possibly invite him to look with a more favourable eye upon the green and immature essays of early writers, if they discover, that the author aims at good things, though he does not yet perform great ones: for, however these youthful productions of the pen are commonly rather pleasing and florid, than otherwise considerable; yet if they be good for their season, and in their kind, though that kind itself be not of the usefulest, they may deserve pardon, and perhaps encouragement; since, though they be not yet solid, they may promise something that will be so; and even the best trees present us their blossoms, before they give us their fruit.

If the same contemplator happens to see young people first shake the tree in vain, then climb it to gather unripe fruit, it may afford him a representation of men's over-eager and untimely pursuits of several desirable things, and especially of honour: for, as green fruit, though of a good kind, will not easily be shaken down by them, that would gather it, but reduces them either to climb the tree or forcibly strike it

off, which commonly bruises, and disfigures what it procures; and as the fruit, when thus obtained, is but sour, and unwholesome, being neither sweetened, nor concocted, by maturity; so that it usually both sets the teeth on edge, and breeds sickness in the body; whereas, if the same fruit were let alone till it were fully ripe, and in season, it would both readily drop into the eater's mouth, and prove delicious, and more wholesome food: so, when we greedily pursue after honour, and pleasure, of which this life is not the proper season, we not only meet with difficulties in acquiring them, but find not, in possessing them, either that satisfaction, or that advantage, that the eagerness of our unruly appetites promises us; whereas, if we would stay contentedly till God's time be come (which is always the best, and fittest) we should not steal, or force, but receive unfading honours, and unclaying delights, by being presented with *incorruptible crowns of glory*, by him, *with whom there is fulness of joy, and at whose right hand* (the station designed for those, that overcome the world's allurements, and their own impatience) *there are pleasures for evermore*; that is, eternal ones.

1 Pet. v. 4.
Psal. xvi.
11.

LASTLY, if towards the end of summer, or of autumn, our reflector, coming to visit his instructive tree, find it present him store of fruit, and perhaps observe it to be grown taller since the last winter, each bough will afford him a lively emblem of a true believer. For, as the loaded branch makes use of the moisture it attracts from the dirty ground, to recede as much as it can from the earth, and spends its sap in shooting up towards heaven, and bearing fruit for men; so the devout Christian improves the blessings he receives of this inferior world, to elevate his mind above it; and the use, that he makes of earthly goods, and advantages, is to raise his grateful soul nearer to God, and dispense them by works of charity to men.

CHAP. V.

THESE, *Sophronia*, are some, and but some, of the thoughts, which the occasional consideration of a fruit-tree might suggest to a considering person. And if we should lead our reflector from the garden to the woods, or to the river-side, or into the fields, or to the street, or to a library, or to the exchange; or, in a word, to I know not how many other places I could name, I have some reason to think, that each of them would supply him with variety of occasional meditations. Wherefore, since the want of themes will not, it is fit that somewhat else should, place bounds to this discourse. And since by finding, that I myself begin to be weary of writing, I have too much cause to fear, that you are quite tired with reading, I think it high time to hasten to a conclusion: only, before I make one, I must do our Meleteticks the right to advertise you, that you would do them wrong, if you should imagine, that in the passed discourse I have either carefully enumerated, or fully displayed, the advantages, which a devout and ingenious contemplator may derive from the exercise of the ways of thinking I have been treating of. For, though I have in the past discourse, especially those parts of it, that are contained in the third precedent, and in this present fourth section, said enough to recommend the subject to any that is not much indisposed to be prevailed with; yet I will not deny, but that, even in those two sections, I have left much unsaid.

For, besides the several advantages and ways of making occasional meditations already pointed at, there are other accounts, upon which the practice I would persuade may both benefit a pious soul, and be made use of by an ingenious one. For the respects one thing may have to another are so numberless, and the mind of a rational man, versed in meditations, may compound and disjoin notions so many ways,

ways, and may make such inferences from them, and such applications of them, that it frequently happens, that besides the reflection, suggested by that which gave the first rise to his meditations, he lights upon conceits differing enough from them, and perhaps better than they: as when hounds, hunting a hare, meet in their way with a stag. For, though philosophers seem to have justly enough rejected the opinion, attributed to *Plato*, that all knowledge is but *reminiscence*; yet certainly the mind of a man, well furnished with variety of notions, is, by the analogy or contrariety of things and notions, in reference to each other, so easily and readily excited to lay them together, and discourse upon them, that he is oftentimes by any slight occasion helped to light (and that with a strange and surprizing facility) upon things, that he would else have scarce taken the least notice of. When the mind is once set on work, though the occasion administered the first thoughts, yet those thoughts themselves may, as well as the object that excited them, become the themes of further meditation: and the connection of thoughts within the mind may be, and frequently is, so latent, and so strange, that the meditator will oftentimes admire to see, how far the notions he is at length led to, are removed from those, which the first rise of his meditation suggested. And by these incidental excursions he may sometimes be as much delighted and surprized, as *Sampson* was, when going aside to look upon the carcase of a lion, he met with a stock of honey.

Judges xiv.
8.

BUT I can add one thing towards the inducing you to exercise your self in the way of thinking we have all this while been speaking of; which though I had almost forgot to take notice of, it will, I doubt not, seem important to *Sophronia*, to whom it need not be a discouragement from aiming at one of the noblest uses of occasional reflections, that it supposes not a bare acquaintance with them, but springs from an entire, and (if I may so speak) intimate familiarity with our Meleteticks. For this use of occasional meditations, though it do but gradually differ from some of those, that have been already mentioned, will perhaps by the devout (and consequently by *Sophronia*) be esteemed the highest advantage, that this way of thinking can confer; and it is, that the custom of making occasional reflections may insensibly, and by unperceived degrees, work the soul to a certain frame, or temper, which may not improperly be called heavenly-mindedness, whereby she acquires an aptitude and disposition to make pious reflections upon almost every occurrence, and oftentimes without particularly designing it. But as this privilege will, as I was intimating, scarce fall to the share of any but those, that, by long or frequent exercise, have so accustomed their minds to reflect upon what they see, that they continue that practice, as it were, of their own accord; so when once, by such a constant kindness and hospitableness to such thoughts, that they will, as it were, come to the mind without calling, and make themselves its guests, without particular invitations, the soul has attained that desirable frame we lately called heavenly-mindedness, which is a disposition and a readiness to make spiritual uses of earthly things, both the advantage and the delight of that frame of heart cannot but be extraordinary. It must surely afford a great deal of satisfaction to an ingenious and devout person, to be able to make the world both his library and his oratory; and which way soever he turns his eyes (not only upon unobvious things, but even upon the most familiar ones) to behold something that instructs, or that delights him; and to find, that almost every object, that presents it self to his notice, presents also good thoughts to his mind, to be gathered with as much innocency and pleasure, and with as little prejudice to the things, that afford them, as honey is gathered by the industrious bee from the differing flowers he meets with in her way. Certainly, if we would carefully lay hold on, and duly manage, this help, it would prove a powerful remedy to prevent or cure much of that

dullness

dullness and drowsiness, that do so frequently smother or blemish our devotion. There would scarce any thing pass us, out of which we would not strike some spark or other of that heavenly fire, or that would not contribute something, either to kindle it, or to feed it, or to revive it. If but half the precious time we impertinently trifle, or squander away upon employments, that will be sure to cost us either tears or blushes, were carefully laid out in the cultivating of this kind of thoughts, it might often save our ministers the labour of insisting so long upon the uses of their doctrines, when the whole world would be a pulpit, every creature turn a preacher, and almost every accident suggest an use of instruction, reproof, or exhortation. No burial but would toll a passing-bell, to put us in mind of our mortality: no feast but would make us aspire to the marriage-feast of the lamb: no cross but would add to our desires to be dissolved, and to be with Christ: no mercy but would be a fresh engagement unto obedience to so good a master, as the author of it: no happiness of others, but would prove an encouragement to serve him, that can give that, and much greater: no misery of others, but would awake and heighten our gratitude, that we are privileged from it: no sin in our neighbours, that would not dissuade us from what we see looked so unhandfomely in others: nor any virtue of theirs, but would excite our emulation, and spur us on to imitate or surpass it. In a word, when the devout soul is come to make that true use of the creatures, as to look upon them as men do upon water, that the sun gilds with his beams, that is, not so much for it self as for the reflective virtue it has to represent a more glorious object; and when she has, by long practice, accustomed her self to spiritualize all the objects and accidents that occur to her, I see not why that practice may not be one of the most effectual means for making good that magnificent assertion of the Apostle, *That all things work together for good to them that love God*: a devout occasional meditation, from how low a theme soever it takes its rise, being like *Jacob's ladder*, whereof though *the foot leaned on the earth, the top reached up to heaven*.

Rom. viii.
28.

Gen. xxviii.
12.

OCCASIONAL REFLECTIONS.

SECT. I.

REFLECTION I.

Upon his manner of giving meat to his dog.

IGNORANTLY thankful creature, thou beggest in such a way, that by what would appear an antedated gratitude, if it were not a designless action, the manner of thy petitioning before-hand, rewards the grant of thy request; thy addresses and recompence being so made and ordered, that the meat I cast thee may very well feed religion in me. For, but observe this dog, I hold him out meat, and my inviting voice loudly encourages and invites him to take it: it is held indeed higher than he can leap; and yet, if he leap not at it, I do not give it him; but if he

he do, I let it fall half way into his mouth. Not unressemblingly deals God with us ; he shews and holds forth to us (the soul's true aliment) eternal glory, and his most gracious word summons and animates us to attempt it. Alas ! it is far above the reach of our endeavours, and our deserts ; and yet if we aspire not to it, and strive not for it, in vain do we expect it ; but if we faithfully do what in us lies, and our endeavours strain themselves to their utmost, God mercifully allows the will for the effect, measures our performances by what they aimed at, and favourably accepting what we can do, for what we should do, he supplies the imperfections of our faint, but yet aspiring attempts, by stooping condescensions ; and what our endeavours want of reaching up to, his grace and acceptation brings down. Piety is the condition, though not the price, of heaven ; and (like the wedding garment in the parable) though it give us not a right to the beatifick feast, is yet that, without which none shall be admitted as a duly qualified guest : for though we cannot reach heaven by our good works, we shall not obtain it without them.

REFLECTION II.

Upon his distilling spirit of roses in a limbeck.

ONE, that knew how well I love the scent of roses, and were ignorant of the uses of this way of distillation, would, questionless, think me very ill advised, thus hastily to deprive my self of the flowers I most love, and employ art to make them wither sooner than nature would condemn them to do : but those that know, both the fading condition of flowers, (which, unimproved by art, delight but whilst they are, what they cannot long be, fresh) and the exalting efficacy of this kind of distillation, will think this artificial way, that chymists take, of spoiling them, is an effect as well of their providence as their skill : for that pleasing and sprightly scent, that makes the rose so welcome to us, is as short-lived and perishing, as the flower, that harbours it, is fading ; and though my limbeck should not, yet a few days inevitably would, make all these roses wither. But by this way of ordering my roses, though I cannot preserve them, I can preserve that spirituous and ætherial part of them, for whose sake it is, that I so much prize and cherish this sort of flowers ; which, by this means, I preserve, not indeed in the fading body, but in the nobler and abstracted quintessence ; which purer and lasting portion of them will be more highly fragrant than ordinary roses are wont to be, even whilst they are fresh, in that season, when those flowers, that have not been thus early and purposely destroyed, will, according to the course of nature, whereto they are left, wither and putrify.

Thus he that sees a charitable person liberally part with that money, which others are so fond of, if he be a stranger to the operations of faith, and the promises of the gospel, he will be apt to mistake the Christian's liberality for folly, or profusion, and to think that he is fallen out with his money : but he that remembers, how clear a prospect, and how absolute a disposal of the future, the Scripture of truth (to use an angel's expression) ascribes to him, that bid his disciples *make themselves friends with the uncertain (or unfaithful) mammon*, (for so the use I sometimes meet with of the Greek word, together with the context, invites me to render it) *that when he fail, they may receive us into everlasting habitations* ; and he that shall likewise consider, not only the transitory nature of worldly possessions, (from which their perishing, or ours, will be sure ere long to divorce us) but the inestimable advantage, with which we shall receive in heaven whatever we employ in pious uses here on earth, will conclude this way of parting with our wealth the surest and gainfullest way of preserving it ; since the Christian, by parting but with what (however) he could not long keep, shall,

shall, through God's munificent goodness, obtain a much more valuable treasure, that he shall never lose: so that thus to sacrifice wealth to charity is not an early loss of it, but the right way of securing it; for by this gainful way, when we shall, in another world, be past the possibility of possessing our riches in kind, such an employment of them may help us to enjoy them, though not in the capacity of riches, yet in that noble capacity of goods, under which notion alone they are desirable; and thus laid up they may there procure us, what they could never here afford us, happiness.

REFLECTION III.

Upon his being in great danger wandering, on Mendip hills, among covered lead mines, that he knew not of.

HOW have I travelled all this while upon the brink of the grave! I thought only to be out of my way, but little dreamed to be so near the end of all my journeys, in that of my life by traversing to and fro amongst those deep and covered pits, upon any one of which if my horse had but chanced to stumble, (and the very mine-men I at length met with, think it a kind of miracle he did not) I had been killed and buried at once, and my fate had been for ever as much concealed from my friends as my body: and all this escape a work so totally of God's goodness, that I did not so much as know my danger till I was past it; so that it seemed sent, but to give me occasion of rejoicing in my deliverance. How vast a debt of gratitude then do I owe to God? and how extremely do I fall short of acquitting myself of it? since, besides that I make him but very unsuitable returns for the blessings I know I have received, I receive from him signal blessings, that I do not so much as know of, and which consequently I am very unlike particularly to acknowledge. But this gracious rescue, from so great and unexpected a hazard, shall, I hope, teach me henceforth to beware, both of security, since I often fall into dangers that I know not, and of distrusts of God's providence, since I have found it so watchful to deliver me from those that I feared not.

REFLECTION IV.

His horse stumbling in a very fair way.

HERE is a patch of way, to which any less smooth than a bowling-green were rugged, and in which it seems not only so unlikely, but so difficult, for a horse to trip, that nothing could have made me believe a horse could have stumbled here, but that mine has dangerously done so. This jade has this very evening carried me safely through ways, where stumbles were so much to be expected, that they were to have been forgiven; and now in a place so smooth, that sure he could not falter in it, only out of curiosity and trial, he falls under me so lubberly, that I as much admired my escape as danger. But it is too usual with us, unfaltering to traverse adversity's rough ways, and stumble in prosperity's smoothest paths. The observation is almost as old as prosperity, that fortune ruins more persons whilst she embraces them, than whilst she would crush them: but though the observation be very common, it is not more so, than it is to see even those, that make it, add to the instances that justify it. I have seldom yet been so fortunate, as to be obnoxious to that less frequently pitied than disarming danger: Fortune has seldom yet vouchsafed to turn Syren to pervert me; and she has hitherto given me much more exercise for my con-

PROV. xxiv.
16.

stancy than for my moderation. I think too, that without slandering my self, I may confess, that I have sometimes wished my self in the lists with that bewitching enemy, prosperity; and increased the number of those many, who never think so fair an adversary formidable, till they find themselves vanquished by her: but upon second thoughts, I judge it better, to leave the choice of my antagonist to him, who not only best knows my strength, but gives it me; especially, when I consider, that as we are all of us naturally such stumblers, that (as *Solomon* speaks in somewhat another sense) *even the just man falls seven times a day*, so it is observed in stumblers, that they are most so in fair way; into which if providence lead my steps, I shall think it seasonable to pray, *and lead us not into temptation*; and shall not think it unseasonable to remember, that ice is at once the smoothest and the slipperiest of ways, and that (the jadedness of our natures well considered) there is no way, wherein we ought to travel with more heed, than that, whose treacherous evenness would divert us from taking heed to our way.

REFLECTION V.

Upon two very miserable beggars, begging together by the high-way.

BEHOLD this fore-most wretch, whose strange deformity and ghastly foreshadow equally exact our pity and our horror; he seems so fit an object for compassion, that not to exercise it towards him can scarce proceed from any other cause than the not having any at all: the sadness of his condition is augmented by his want of eyes to see it; and his misery is such, that it calls for an increase of pity, by his being so distracted, as to desire a longer life, or rather longer death: he sues more movingly to the eye than to the ear; and does petition much less by what he says, than what he is: each several member of his tortured body is a new motive to compassion, and every part of it so loudly pleads for pity, that (as of scolds) it may (in another sense) be said of him, that he is all tongue. But yet this other beggar thinks not his condition the less deplorable for his companion's being the more so: he finds in the diseases of his fellow as little consolation as cure; nor does he at all think himself supplied with a deficient hand, because the other wants one. And therefore he is as importunate for relief, as if all miseries were not only heaped on him, but confined to him: his fellow's burthen lightens not his load; and if fortune never had persecuted any other, he could not more deplore nor resent her persecutions. So that, if we should judge of their miseries rather by the ear than by the eye, this latter's sadder complaints would move us to decree him the advantage in point of wretchedness.

TRANSLATE now, my soul, all this unto spirituals; and as we measure the straightness of lines, not by a ram's horn, but a ruler; so be not thou so rash, as to infer thy health from others more forlorn and desperate diseases. Let not the greater difficulty of another's cure lessen the solicitousness of thy care for thine, nor make thee less earnest in the imploring and labouring for relief. In so depraved an age as ours, one may (and perhaps in vain too) search hell to find wicked men than are to be, but too frequently, met with upon earth: he will scarce be innocent, that will think himself so, as long as he finds a man more culpable than he; and he shall scarce ever judge himself guilty, whom the sight of a guiltier will absolve. Nor will that man (till it is perhaps too late) be apt to attempt an escape from the pollutions of the world, that stays till he can see none more inextricably intangled in them than himself. Do not therefore, O my soul, content thyself with that poor comparative innocence, that in heaven (which it will never bring thee to) has no place, by reason of the absence

absence of all vicious persons; and in hell itself (which it secures not from) can afford only the ill-natured consolation of not being altogether as miserable, as the wretchedest person in that place of torment.

REFLECTION VI.

Sitting at ease in a coach, that went very fast.

AS fast as this coach goes, I sit in it so much at ease, that whilst its rapid motion makes others suspect, that I am running for a wager, this lazy posture, and this soft seat, do almost as much invite me to rest, as if I were a-bed. The hasty wheels strike fire out of the flints they happen to run over; and yet this self-same swiftness of these wheels, which, were I under them, would make them crush my bones themselves into splinters, if not into a jelly, now I am seated over them, and above their reach, serves but to carry me the faster towards my journey's end. Just so it is with outward accidents, and conditions, whose restless vicissitudes but too justly and too fitly resemble them to wheels: when they meet with a spirit, that lies prostrate on the ground, and falls groveling beneath them, they disorder and oppress it; but he, whose high reason, and exalted piety, has, by a noble and steady contempt of them, placed him above them, may enjoy a happy and a settled quiet, in spite of all their busy agitations; and be so far from resenting any prejudicial discomposure from these inferior revolutions, that all those changes, that are taken for the giddy turns of fortune's wheel, shall serve to approach him the faster to the blest mansion he would arrive at.

REFLECTION VII.

Upon the sight of a windmill standing still.

GENORIO, EUSEBIUS, LINDAMOR.

GEN. YOUR eyes, gentlemen, have been so long fixed upon this windmill, that, in spite of the barrenness of the subject, I cannot but suspect, it may have afforded one, or each of you, an occasional meditation.

EUSEB. To justify your conjecture, *Genorio*, I will confess to you, that I was considering with myself, that if one, who knew not the miller's trade and design, should look upon this structure, he would think the owner worthy of so incommodious a mansion, if not of a room in *Bedlam*; for, we see, he has chose to erect this fabrick in a solitary place, and upon the cold and bleak top of a swelling ground, where nothing shelters it from the violence of a wind, whilst its high situation exposes it to the successive violences of them all. But he that is acquainted with the exigencies of the miller's design and trade, will think he has made a proper choice, in seating himself in a place, where no wind can blow, that he shall not be able to make an advantage of. And having considered this, *Genorio*, my thoughts, when you interrupted them, were making this application of it; that we ought not to be too forward to censure men, otherwise virtuous, and discreet, for engaging themselves, upon some accounts, to troublesome and unsettling employments: for if the end be not mischosen, the means are to be estimated by their tendency thereunto; and though a calmer condition of life might be in itself more desirable, yet when a more exposed one can make him, that is qualified for such employments, more serviceable in his generation, this may, upon that account, be more eligible than the other; since, as it exposes him to more hardships, it affords him more opportunities of prosecuting his

his aims; so that his station is recommended to him by those very circumstances, that make other men dislike it.

GEN. But may not I also know what thoughts this worthy theme suggested to *Lindamor*?

LIND. I was, *Genorio*, taking notice, that this whole fabrick is indeed but a large engine, where almost every thing, as well as the sails and the wheels, is framed and fitted for the grinding of corn: but though this whole structure be artificially enough contrived, yet it can now do nothing in order to its end, for want of such a light and airy thing as a breath of wind, to put all this into motion. And, *Genorio*, this wind-mill, thus considered, brought into my mind the condition of a great lord, that you and I not long since visited, and who is far from being the only person, to whom the reflection may be applicable; for one, that not knowing his humour, and his aims, should see how great a provision his plentiful fortune, and his skill to manage it, have laid together, of those things, which are wont to be thought the chiefest instruments (and, perchance, the chief parts) of happiness, would be apt to envy his condition, as discerning nothing that is wanting to it. But alas! the man expects and covets esteem and reputation; and though fame have these resemblances to the wind, that it is an airy and unsolid thing, which we must receive from others, and which we are not only unable to procure for our selves, but know not how long we shall keep it when we have it; yet the want of this alone makes all the rest utterly insufficient for his satisfaction. Thus the not so great as ambitious *Alexander*, after all the blood he had spilt in conquering the world, is said to have shed tears, that he had conquered but one, when a philosopher told him there were more. And all the favours, that the greatest potentate upon earth could heap upon proud *Haman*, were, by his own confession, unable to make him think himself happy, as long as he could not neglect a captive's neglect of him; all his greatness did him no good, if but one man had the courage not to bow to it; and an unsatisfied appetite of revenge quite spoiled the relish of the great monarch's favours, and the fair *Esther's* banquets. Nor do I doubt, *Genorio*, that we often marvel, if not repine, at providence, upon a great mistake; for by refusing to be God's servants, men usually become so to their own unruly passions, and affections. And therefore we often very causelessly envy the great and rich, as if they were as happy as the advantages vouchsafed them, would make a wife and good man; whereas perhaps the man courts a reputation, that is not to be acquired by what men have, but by what they are, and do; or else he is in love with a lady, that loves not him, or loves another better: and the coyness of a mistress, the greater title of a neighbour, or some such trifling accident, that another would either not be subject to, or not be much concerned for, will keep him from enjoying any of those very things, for which by-standers envy him: so just it is, that in estimating a man's condition, we should not only consider what possessions he has, but what desires.

REFLECTION VIII.

Upon his paring of a rare summer apple.

HOW prettily has curious nature painted this gaudy fruit? Here is a green, that emeralds cannot, and *Flora's* self might boast: and *Pomona* seems to have affected, in the fresh and lively vermilion that adorns this smooth rind, an emulation at rubies themselves, and to have aimed at manifesting, that she can give her vegetable productions as lovely and orient, though not as lasting colours, as those that make jewels precious stones; and if, upon the hearing the praises this scarlet deserves, her blushes

blushes ennoble her own cheeks with so vivid a colour, perhaps such a livery of her modesty might justify her pride. In a word, such pure and tempting green and red dye this same polished skin, that our vulgar boldness must be no longer questioned, for rendering that fruit an apple, that inveigled our first parents. But though these winning dyes delight me strangely, they are food for my eye alone, and not my stomach; I have no palate for colours; and to relish this fruit well, and know whether it performs to the taste what it promises to the sight, and justify that Platonick definition, which styles beauty the lustre and flower of goodness, all this gay outside is cut and thrown away, and passes but for parings. Thus, in opinions, though I look with pleasure on that neat fashionable dress, that smoother pens so finely cloathe them with; and though I be delighted with the pretty and spruce expressions, that wit and eloquence are wont to trick them up with; yet when I mean to examine their true relish, that, upon liking, I may make them mine, I still strip and divest them of all those flattering ornaments (or cheating disguises rather) which so often conceal or misrepresent their true and genuine nature, and (before ever I swallow them) after they have been admitted by the more delusible faculty we call fancy, I make them pass the severer scrutiny of reason.

REFLECTION IX.

Upon his coach's being stopt in a narrow lane.

HERE, for aught I can guess, my stay is like to be long enough, to afford me the leisure of a reflection on it: for I have found already, in this narrow lane, a very large scene to exercise my patience in; and this churlish drayman seems resolved to be as tedious to me, as *Ludgate-Hill* is to his horse, when his cart is overladen. They, that are going on foot to the same place this coach should carry me to, find not their passage hindered, or their way obstructed by that, which keeps me here; and were I disposed to leave my coach behind, and foot it after them, I might in their company sooner reach the place my designs and affairs call me to, than I shall (probably) be supplied with hopes of getting quickly out from hence. Alas! how frequently falls it out thus in our journeys towards heaven? Those, whom their adverse fortune, or a noble scorn, hath stript of, or released from, these troublesome and intangling externals, may tread the paths of life nimbly and chearfully, being unstoppt by many obstacles, that intercept the progresses of others. But those stately persons, whose pride or effeminacy will not permit them to move an inch towards heaven, unless they may be carried thither in pleasure's easy coaches, and who will not bate a superfluity, or lay by the least circumstance or punctilio of grandezza, to lessen themselves into a capacity of entering in at the strait gate, may soon find these treacherous and over-loved conveniencies turned into cumbersome clogs, and real impediments, that will, if not block up, at least obstruct the passage to the seat of so much joy; that even to be cast ashore there, by shipwreck, were a blessing; and that he is thought unworthy to be admitted there, that cannot think it his happiness to reach that place himself, though he leave all behind him to get thither.

REFLECTION X.

Looking through a perspective glass upon a vessel we suspected to give us chase, and to be a pirate. [Sailing betwixt Rotterdam and Gravelend on Easter-day, 1648.]

THIS glass does indeed approach the distrusted vessel, but it approaches her only to our eyes, not to our ship; if she be not making up to us, this harmless instrument

instrument will prove no loadstone to draw her towards us; and if she be, it will put us into a better readiness to receive her. Such another instrument in relation to death is the meditation of it; (by mortals so much, and so causelessly, abhorred :) for though most men as studiously shun all thoughts of death, as if, like nice acquaintances, he would forbear to visit, where he knows he is never thought of, or as if we could exempt ourselves from being mortal, by forgetting that we are so; yet does this meditation bring death nearer to us, without at all lessening the real distance betwixt us and him: if that last enemy be not yet approaching us, this innocent glass will no more quicken his pace, than direct his steps; and if he be, without hastening his arrival, it will prepare us for his reception. For my part, my beardless chin allows me to presume, that by the course of nature, I have yet a pretty stock of sand in the upper part of my hour-glass: wherefore, though I am now too young to say with *Isaac*, *Behold, now I am old, and I know not the day of my death*, Gen. xxvii. 2. yet since the youngest and lustiest of us all has cause to say with the mirror of patience, *When a few years are come, then shall I go the way whence I shall not return*, Job xvi. 22. and since it is the wise man's counsel, *Not to boast ourselves of to-morrow, because we know not what a day may bring forth*: I will endeavour (to use our Saviour's terms) *to take heed to myself, lest at any time that day come upon me unawares*, Luke xxi. 34. And, as the only safe expedient in order thereunto, I will (in imitation of holy *Job*) *All the days of my appointed time, wait till my change come*, Job xiv. 24.

S E C T. II.

Containing OCCASIONAL REFLECTIONS upon the
Accidents of an Ague.

M E D I T A T I O N I.

Upon the first invasion of the disease.

THIS visit, dear * *Sophronia*, which you intended but for an act of kindness, proves also one of charity; for though it be not many hours since we parted, and though you left me free from any other discomposure than that, which your leaving me is wont to give me; yet this little time has made so great a change in my condition, as to be, I doubt not, already visible in my looks: for whilst I was sitting quietly in my chamber, and was as far from the thoughts of sickness, as from any such disorders, as are wont to be the occasions of it; and whilst I was delightfully entertained by an outlandish virtuoso, that came to visit me, with an account of the several attempts, that are either made, or designed in foreign parts, to produce curiosities, and improve knowledge; I was suddenly surprized with a chillness, and a shivering, that came so unexpected, and increased so fast, that it was heightened into a downright fit of an ague, before I could satisfy myself what it was. But I confess, that this unwelcome accident had not amazed me, as well as troubled me, if I had

* A name often given by the Author to his excellent Sister R. who was almost always with him, during his sickness.

sufficiently

sufficiently considered, to what a strange number and variety of distempers these frail carcases of ours are obnoxious; for, if I had called to mind, what my curiosity for dissections has shown me, and remembred how many bones, and muscles, and veins, and arteries, and gristles, and ligaments, and nerves, and membranes, and juices, a human body is made up of, I could not have been surprized, that so curious an engine, that consists of so many pieces, whose harmony is requisite to health, and whereof not any is superfluous, nor scarce any insensible, should have some or other of them out of order, it being no more strange, that a man's body should be subject to pain, or sickness, than that an instrument with above a thousand strings (if there were any such) should frequently be out of tune; especially since the bare change of air may as well discompose the body of a man, as untune some of the strings of such an instrument; so that even the inimitable structure of human bodies is scarce more admirable, than that such curious and elaborate engines can be so contrived, as not to be oftner out of order than they are; the preservation of so nice and exact a frame being the next wonder to its workmanship. And indeed, when I consider further, how many outward accidents are able to destroy the life, or at the least, the health, even of those, that are careful to preserve them; and how easily the beams of a warm sun, or the breath of a cold wind, or too much, or too little exercise, a dish of green fruit, or an infectious vapour, or even a sudden fright, or ill news, are able to produce sickness, and perhaps death; and when I think too how many evitable mischiefs our own appetites, or vices, expose us to, by acts of intemperance, that necessitate the creatures to offend us, and practices of sin, whereby we provoke the Creator to punish us: when, I say, I consider all this, and consequently how many mischiefs he must escape that arrives at grey-hairs; I confess, the commonness of the sight cannot keep me from thinking it worth some wonder, to see an old man, especially if he be any thing healthy. But these kind of thoughts, *Sophronia*, are seldom entertained, unless they be excited by some unwelcome occasions; and when we are long accustomed to health, we take it for granted, that we shall enjoy it, without taking it for a mercy that we are so: we are not sensible enough of our continual need and dependance on the divine goodness, if we long and uninterruptedly enjoy it; and by that unthankful heedlessness we do, as it were, necessitate providence to deprive us of its wonted supports, to make us sensible, that we did enjoy, and that we always need them: it being but fit, that mercies should cease to be constant, which their constancy only, that should be their indearment, keeps us from entertaining as mercies. I will therefore, *Sophronia*, endeavour to derive this advantage from this sudden fit of sickness, to make me thankful for health, when God shall be pleased to restore it me, and to keep me from reckoning confidently upon the lastingness of it. For though we are very unapt to take even the wise man's counsel, where he forbids us to *boast ourselves of to-morrow, because we know not what a day may bring forth*; yet by such accidents I find, that *Solomon* spoke much within compass, and had not done otherwise, if for a day he had substituted an hour: for so many, and so various are the unforeseen accidents, to which we poor mortals are exposed, that the continuance of our health or prosperity do much more merit our thanks, than the interruption of them can deserve our wonder. And I must confess, *Sophronia*, that though my falling sick may be but my unhappiness, my being so much surprized as it was my fault.

MEDITATION II.

Upon the immoderate heat and cold of the aguish fit.

ONE that, not knowing what ails me, should come in, and see me in this soft bed, not only covered, but almost oppressed with clothes, would confidently conclude, that, whether or no I be distressed by the contrary quality, I cannot at least be troubled with cold; and if he himself were so, he will be apt to envy me. And if, instead of coming in my cold fit, he should visit me in my hot one, and see me with my shoulders and arms quite uncovered, and nothing but the single sheet on the rest of my body; he would be apt to think, that I must lie very cool. But alas! in spite of all that lies upon me, an internal frost has so diffused it self through every part, that my teeth chatter, and my whole body does shake strongly enough to make the bed it self do so; and, though I still wish for more clothes, yet those, that are heaped on me, can so little controul this preternatural cold, that a pile of them might sooner be made great enough to crush, than to warm me; so that when I travelled even in frosty nights, the winter had nothing near so strong an operation on me. And as that external cold was far more supportable whilst it lasted, so it was incomparably more easy for me, by exercise, and otherwise, to deliver my self from it.

THUS, when a great or rich man's mind is distempered with ambition, avarice, or any immoderate affection, though the by-standers, that see not what disquiets him, but see what great store of accommodations fortune has provided for him, may be drawn to envy his condition, and be kept very far from suspecting, that he can want that contentment, the means of which they see him so richly supplied with: and yet alas! as the colder heat of the external air is much less troublesome to a man in health, though furnished with an ordinary proportion of clothes, than the cold or hot fit of an ague, with a pile of blankets first, and then a single sheet; so to a vigorous and healthy constitution of mind, external inconveniences are much more supportable, than any accommodations can make the condition of a distempered soul. Let us not then judge of men's happiness, so much by what they have, as by what they are; and consider both, that fortune can but give *much*, and it must be the mind, that makes that *much enough*: and that, as it is more easy to endure winter, or the dog-days in the air, than in the blood; so a healthful mind, in spite of outward inconveniences, may afford a man a condition preferable to all external accommodations without that.

MEDITATION III.

Upon the succession of the cold and hot fit.

WHEN the cold fit first seized me, methought it was rather melted snow than blood, that circulated in my veins, where it moved so inordinately, and maintained the vital flame so penuriously, that the greatest sign, which was left to distinguish this cold from that of death, was its making me shake strong enough to shake the bed I lay on. I called for more and more clothes, only because I needed them, not because I found any relief by them: I fancied the torrid zone to be of a far more desirable constitution than that we call the temperate; and as little as I am wont to reverence vulgar chymists, I then envied their laborants, whose employment requires them to attend the fire. But when the cold fit was once over, it was quickly succeeded by a hot one, which after a while I thought more troublesome than it.

I threw

I threw off the clothes much faster than my former importunity had procured them to be laid on me; and I, that could a little before scarce feel all that had been heaped on me, could not now support a single sheet, but thought its weight oppressed me.

I ENVIED the inhabitants of *Norway*, and *Iceland*, far more than those, that dwell either in the richest province of *East India*, or of the Golden Coast it self: and of all creatures, not rational, I thought the fishes the happiest, since they live in a cool stream, and, when they please, may drink as much as they list.

If then, *Sophronia*, the self-same person may, within less than two hours, have such different apprehensions of his own condition, as now to complain of that as a sad grievance, which but an hour before he wished for as a relief; we may well acknowledge, that we frequently mistake in estimating the hardships and afflictions we complain of, and find them not so uneasy as we make them, whilst we not only endure the whole affliction, that troubles us, but often increase it, by repining at the envied condition of others.

AN afflicted man is very apt to fancy, that any kind of sickness, that for the present troubles him, is far less supportable, than if it were exchanged for another disease; and imagines his case to be so singular, that one cannot say to him in St. Paul's language, *No temptation has befallen you, but that which is common to men*, 1 Cor. x. 13. He presumes, that he could far more easily support his crosses, if instead of his present disease, he had this or that other; though, if the exchange were made, he would, perchance, wish for his first sickness, if not be as much troubled at his own folly, as with the disease. He that is tormented with the gout, is apt to envy any sick man, that is exempted from that roaring pain, and able to walk about: he that is swelled with the dropsy, fancies all persons happy, whose diseases allow them drink to quench their thirst: and the blind man envies both these, and thinks no persons so miserable in this world, as those that cannot see the world. Fevers burn us, agues shatter us, dropies drown us, phrenies unman us, the gout tortures us, convulsions wrack us, epilepsies fell us, colicks tear us; and in short, there is no considerable disease that is not very troublesome in it self, however religion may sanctify and sweeten it: for as a fortress, whose defendants are not treacherous, can scarce be taken otherwise than either by famine, or storm; so life, for whose preservation nature is so faithfully solicitous, cannot be extinguished, unless either chronical diseases do lingeringly destroy, or some acute do hastily snatch it away. And indeed, if a disease prove mortal, it is no more than is to be expected, if it tire out the patient with tedious languishments, or else dispatch him with dismal symptoms: nor is it in point of sickness only, that we are often more unhappy than we need, by fancying ourselves more unhappy than we should be, if we were allowed to exchange that, which now troubles us, for any thing which does not. But there are evils, which, though exceeding contrary in appearance and circumstances, do yet agree in being extremely troublesome; as the poorest wretch our Saviour cured in the Gospel, though he were sometimes cast into the fire, and sometimes into the water, yet in both states was tormented by the same devil, who, in variety of afflictions, still expressed the same malice. But we should make a righter estimate of suffering, if we did but consider, that much uneasiness is annexed to an afflicted condition in general; and that therefore, which we are sensible of, may proceed rather from the general nature of sicknesses, and crosses, than from the particular kind and degree of ours. And indeed, if a man were permitted to exchange his disease with those of others, he would often find his granted wishes to bring him a variety of mischiefs, rather than an exemption

from them; and many of those, that we envy, as thinking them far less sufferers than our selves, do look with invidious eyes on us, and do but dissemble their grievances more handsomely than we, not find them more easy than ours. And that of St. Peter may be more generally applied, than most men think, where he exhorts to constancy, upon this consideration, *That the same sufferings are accomplished upon our brethren in the world*, 1 Pet. v. 9. For it is all one as to the efficacy of this lenity, whether our afflictions be the same with those of others, in kind, or not superiour to them in degree: and I doubt not, but we should support many of our grievances as easily as those, for which we wish them exchanged, if the chief account, upon which they trouble us, were not rather, that they are the present ones, than the greatest.

MEDITATION IV.

Upon the being let blood.

ONE of the most troublesome symptoms in almost all feverish distempers is wont to be thirst; and in mine it was importunate to a degree, that made me very much so, in frequently soliciting those, that were about me for drink, which, in the heat of the fit, seemed so desirable an object, that it then much lessened my wonder at that parched king's agreement, who, urged with thirst, sold his liberty for a full draught of cold water. But alas! I sadly found, that the liquor I swallowed so greedily, afforded me but a very transient relief, the latter being gone almost as soon as the former had passed thorough my throat; so that not only it did but amuse me, not cure me; but, which is worse, drinking it self increased my thirst, by increasing the fever, whose uneasy symptom that was. Wherefore, seeing all the cooling juleps that could be administered, did free me from nothing but the expectation of being much relieved by such slight and palliative medicines; the doctor thought himself this day obliged to a quite contrary, and yet a more generous remedy; and ordered, that, instead of giving me drink, they should take away blood, as judging it the best and far the surest course to take away the uneasy symptoms, by removing that, which fomented the cause.

Thus when the mind is distempered with turbulent commotions, and the disquieted appetites do too restlessly and eagerly crave objects, which, though perhaps in themselves not absolutely bad, are at least made, by a conjunction of circumstances, unfit and dangerous for the person that longs for them: we, like unskilful or unruly patients, fondly imagine, that the only way to appease our desires is, to grant them the objects they so passionately tend to. But the wise and sovereign physician of souls, who considers not so much what we do wish, as what we should wish, often discerns, that this præternatural thirst indicates and calls for a lancet, rather than a julep, and knows it best to attempt the cure, rather by taking away somewhat that we have, than by giving us that, which only a spiritual superfluity reduces us to want. And in effect, we often see, that as a few ounces of blood taken away in a fever do cool the patient more than the giving him ten times as much drink would do; so a few afflictions, by partly letting out, and partly moderating our corrupt affections, do more compose and appease a mind molested with inordinate appetites, than the possession of a great many of the objects we impotently desire. Whilst our appetites are roving, and unreasonable, and insatiate, the obtaining of this or that particular object does but amuse the patient, not take away the disease; whereas seasonable and sanctified crosses, that teach us to know our selves, and make us sensible how little we deserve, and how little the things we are so greedy of could make us happy, if obtained,

obtained, may reduce us to a resignation, and tranquillity of mind, preferable to those over-valued things, which, as it keeps us from enjoying, so it keeps us from needing. Thus *Zaccheus*, who, whilst a publican, never thought he had enough, when he had once entertained our Saviour, though he offered to make a quadruple restitution of whatever he had fraudulently acquired, was, upon a sudden, by being freed from avarice, grown so rich, that he was forward to give no less than half he had to the poor; as if his divine guest had wrought upon his goods such miracles, as he had done upon the five loaves, and two fishes, of which the remains amounted to more than the whole provision was at first.

MEDITATION V.

Upon the taking of physick.

THE last bitter potion that I took, *Sophronia*, was, I remember, sweetned with the hopes that were given me with it, that it might prove the last I should need to take, and would procure me a settled and durable health: but I find by sad experience, that the benefit I derived from it is nothing near so lasting as it was welcome; for I am now reduced to take physick again, and I fear must often do so, before I shall be able to dislodge this troublesome ague that haunts me. For though the last physick I took, wrought so well, that I hoped it had brought away not only the ill-humours themselves, but the very sources of them; yet by the effect of what I took this morning, I not only find there is as much to be purged away now, as there was then, but, what is sadder, I can scarce hope this physick will excuse me from the need of taking more again ere long. But though it is a troublesome thing, and must be often repeated, yet it is a salutary thing too, and cannot be more unpleasant than it is useful; and as loathsome as it is, a sickness were far worse. Thus when a relenting sinner has endeavoured to wash away his sins with his tears, he may possibly think himself so thoroughly washed in that absterfivè brine, (which yet owes its cleansing virtue not to its own nature, but to the blood of Christ) that if he be a new convert, and be entertained with those ravishing delights, wherewith God is often pleased to engage such returning prodigals, (as the kind father welcomed his riotous son with feasting, and with musick) that he is apt to fancy repentance to be like baptism, which, being received once for a man's whole life, needs never be renewed. But though, during such transports, an unexperienced convert may be apt to cast the gauntlet to the world, saying in his spiritual-prosperity, that he should never be moved; yet, as our Saviour speaks, *The spirit indeed is willing, but the flesh is weak*: and too commonly our resolutions flag with our joys, and those that a while before imagined they despised the world, find themselves worsted, if not captivated, by it; and find it far more difficult than they thought it, to live in the company of sinners without being of their number, and in so defiled a world without being spotted by it.

AND as the same *David*, who said in his prosperity, he should never be moved, said in his distress, he should one day perish by the hand of *Saul*; so many of those, that whilst their tears of repentance, and of joy, are not yet dried off their eyes, are apt to defy and contemn all the ghostly enemies, and difficulties, that oppose their present zealous resolutions, will, perhaps, in a while after, when they meet with unexpected impediments, and foils, change their confidence into despair, and think those very enemies, whom they lately looked on as despicable, to be insuperable. But as physick, that does good for a time, ought not to be rejected, because it does good but for a time; nor should we reject the only sure means of our present

recovery, for fear of future relapses : so, though we sadly find, that repentance must be repeated, and that after we have practised it often, we must have need of it again; yet since it is the only proper means to recover a soul out of a state of sin, which is worse than any disease, and leads to the worst of deaths, we must never suffer our selves to be so far discouraged, as to forego so necessary and so profitable a duty, and must not more frequently relapse into faults, than renew our sorrow for them, and our resolves against them: for innocence indeed is far more desirable than repentance, as health is than physick. But as physick is more eligible than the continuance of sickness, so is repentance more eligible than continuing in the state of sin: and as the drinking even of a bitter potion is a less evil than the heat, and thirst, and restlessness of an ague; so to lament for sin here, is a far less uneasy thing, than to do it in a place, where there is nothing but remediless wailing, and gnashing of teeth. It is true, that our souls are in this too like our bodies, that our whole lives are spent betwixt purging away of naughty humours, and accumulating them: and methinks, I hear the flesh still saying unto the spirit, as *Ruth* did to *Naomi*, *the Lord do so to me, and more also, if aught but death part thee and me*, *Ruth* i. 14. But although there are defilements, which, though often washed off, will as often come again to blemish us; and though the *deeds of the * body* will scarce all of them perfectly be put to death, but with the body it self; yet next to an uninterrupted state of health, frequent and early recoveries are desirable: and though the shameful necessity of needing to beg many pardons for the same fault may justly make an ingenuous Christian cry out with Saint *Paul*, *O wretched man that I am! who shall deliver me from the body of this death?* yet the same sense of his own frailty, that puts this exclamation into his mouth, may comfort his heart, by its being a pledge, that he shall one day be able exultingly to say with the same Apostle in another place, *Thanks be to God, which giveth us the victory, through our Lord Jesus Christ*, 1 Cor. xv. 57.

Rom. viii.
13.

* *Operation*.

MEDITATION VI.

Upon the syrups and other sweet things sent him by the Doctor.

THIS complaisant physician, *Sophronia*, is, you see, very solicitous, that his remedies should as well gratify the patient, as oppose the disease: and besides that this julep is tinged with syrup of clove-july-flowers, that it may at once delight the palate, and the eye; some of these other remedies are sweetned with as much sugar, as if they came not from an apothecary's shop, but a confectioner's. But my mouth is too much out of taste to relish any thing, that passes through it; and though my sickness makes this flattering of the palate almost necessary to the rendring these medicines takable by me, yet upon the account of the same distemper, all that the Doctor's tenderness and skill could do to make them *pleasant*, can at most but keep them from being *loathsome*. And therefore you will easily believe, *Sophronia*, that I enjoy these sweet things upon a score, that, if it does imbitter them, does at least, as to me, deprive them of their nature: so that he, that, for the sake of these syrups and electuaries, should, notwithstanding the malady that needs them, envy me, might be suspected to be troubled with a worse disease than an ague is, a frenzy.

Thus there are many favourites of fortune, whose seeming enjoyments may, perchance, be envied by those, that do but gaze on their condition, whilst it is rather pitied by those that know it. To be brought by greatness of power, or riches and effeminacy of mind, to that pass, that they seldom hear any thing but their own praises,

praises, even when their actions merit reprehension, and that they can relish nothing that is not sweetened with so much of flattery, as quite to disguise, and perhaps pervert, its nature: these, as I was going to say, and such other unhappy privileges, are things, which (whatever fools may think) will not recommend greatness to a considering man, and are far more fit to procure the possessor's ruin, than wise men's envy: and besides that a vain and impotent soul is, by those disquieting qualities, molested with greater distempers, than those gratifications can make amends for, and which often hinder the full relishing of these or any other pleasures. The delight these treacherous delicacies afford, is so much less considerable than the weakness they suppose; that it is far more eligible to be without them than to need them.

MEDITATION VII.

Upon the want of sleep.

AH! dear *Sophronia*, in spite of all the care and officiousness of those diligent attendants, that you were pleased to send to watch with me, I have slept all night as little as I do now, or as I shall desire to do whilst you stay here.

THIS unwelcome leisure brought me as much a necessity, as an opportunity to spend the time in entertaining my thoughts, which on this occasion were almost as various, and seemed too as wild, as, if I had slept, my dreams themselves would have been: and therefore, I presume you will not wonder, if I can now recall but few of them, and if the rest be as easily vanished out of my memory, as they came abruptly into my mind.

THE first thought, that I remember entertained me, was that, which was the most naturally suggested by the condition I was in: for when I found how tedious and wearisome each hour was, and observed how long a time seemed to intervene betwixt the several divisions, that the striking of the clock made of a night, that must at this time of the year be much shorter than the day; I could not but consider, how insupportable their condition must be, to be cast into outer darkness, where tormented wretches lie, not as I do upon a soft bed, but upon fire and brimstone, where no attendance of servants, or kindness of friends, is allowed them, that need it as much as they deserve it little; and, which is worst of all, where no beam of hope is permitted to console them, as if the day should dawn after so dismal a night, though protracted to millions of ages, each of whose miserable hours appears an age.

THE next thing I was considering, was, how defective we are in point of gratitude to God: I now blush, that I cannot call to mind the time, when I ever thought, that his having vouchsafed me the power of sleeping deserved a particular acknowledgment. But now I begin to see, that it is our heedlessness, not their uselessness, that keeps us from daily being thankful for a multitude of mercies, that we take notice of; though it be injurious, that that only commonness, that heightens the benefit, should keep us from being sensible of the greatness of it. I confess I was very lately one of them, who looked upon sleep as one of those inconveniences of human nature, that merit a consolation; and I very little apprehended, that I should ever complain of the want of sleep, as of a grievance, the necessity of it being what I always looked upon under that notion. But I now perceive, he was a wise man, who said, *That God made every thing beautiful in its season.* And yet, when I consider the affinity betwixt sleep and death, whose image it is, I cannot but think it very unlikely

unlikely, that this life should be designed for our happiness, since not to lose almost half of it were an infelicity.

ANOTHER thing I remember I was considering, was this, that though want of sleep be one of the uneasiest accidents, that attend on sickness, yet in many cases it proves as useful as it can be unwelcome. For there is a sort of jolly people, far more numerous than I could wish them, who are at utter defiance with thinking, and do as much fear to be alone, as they should to do any course, that is naturally productive of so unmanly a fear: and the same sinful employments, or vain pastimes, that make them afraid of being alone, do so much keep them from the necessity of being so, that they keep them almost from the very possibility of it. For in the time of health, visits, businesses, cards, and I know not how many other avocations, which they justly style diversions, do succeed one another so thick, that in the day there is no time left for the distracted person to converse with his own thoughts: and even, when they are sick, though they be debarred of many of those wonted diversions, yet cards and company will give them enough to prove a charm against thinking, which the patient is so willing, or rather sollicitous, to decline, the need of that sickness less troubles him, as it keeps his body from going abroad, than as it tends to drive his thoughts home; so that sickness does little or nothing towards the making such men consider, by casting them upon their beds, unless it also hinder them from sleeping there. But in the long and tedious nights, when all the praters, and the gamesters (who are usually called good companions, but seldom prove good friends) are withdrawn, and have left our patient quite alone, the darkness of the night begins to make him discern, and take some notice of his own condition, and his eyes, for want of outward objects, are turned inwards, he must, whether he will or no, during the silence of the night, hear those lessons, which by the hurry and avocations of the day he endeavoured to avoid. And though this be a very unwelcome mercy, yet it is a mercy still, and perhaps the greater for being so unwelcome: for if he could sleep in sickness, as he used to do in health, he were in great danger of having his conscience laid asleep, till it should be awaked by the flames and shrieks of hell. And the design of God in chastening being to reclaim and amend us, we not only do, by our want of reflecting, endure the trouble of sickness, without reaping the benefit of it; but also by our shunning to consider, we are so ill-natured to our selves, as to lengthen the sickness, we are so impatient of; which is in us as foolish, as it would be in a nice patient, after having been made to take a bitter, but a salutary potion, to send unseasonably for cordials and juleps to hinder the working of it, and so by such unruliness lose the benefit of the operation, and lengthen his pain and sickness, to avoid the far less trouble of complying with the nature of the medicine, and the designs of the physician: so that repentance being necessary to recovery, and the considering of a man's own ways as necessary to repentance, the want of sleep, which both allows us time, and imposes on us a necessity to think, may well be looked upon as a happy grievance, since it very much tends to the shortning of our afflictions, by the disposing us to co-operate towards God's aims in sending them.

MEDITATION VIII.

Upon telling the strokes of an ill-going clock in the night.

THE same violence of my fit, that made me very much need sleep, allowed me so little of it, that I think I missed not hearing one stroke of the clock all the night long. But since you know, *Sophronia*, that the clock is kept by the soldiers, that

that are quartered in the place where it stands, you will easily believe, that it is not very carefully looked to; especially since they are not only wont to let it go ill, but do oft times make it do so on purpose, and as may best comply with the officers occasions, and as they would have the guards, that are to be set here, or to be sent hence, sooner or later relieved. Of this uncertain going of the clock I never had occasion to take so much notice as the last night, when, lying too constantly awaked, I began to observe, that though all the hours were so tedious, as to seem every one of them extraordinarily long, yet they manifestly appeared to me not to be equally so; and therefore, when the clock struck eleven, to satisfy my self, whether it did not mis-inform me, I called to one that sat up by me for the watch I use to measure the time with in nice experiments, and found it to want but very little of midnight; and not much above an hour after, when by my watch it was but about one, those that kept the clock, whether out of negligence, or design, or to make amends for past slowness, made it strike two; which seemed to me to hint a not unuseful rule in estimating the length or shortness of discourses: for there are cases, where the difficulty or importance of the subject is such, that though it cost a man many words, yet if what he says be not sufficiently fitted to the exigency of the occasion, and the theme, he may speak much, without saying enough. But on the other hand, if (as it often happens) a man speak either unseasonably, erroneously, or impertinently, he may, though he say little, talk too much; the paucity or number of words is not, as many think it, that, which is in such cases to be chiefly considered; for it is not many, or few, that are required, but enough. And, as our clock struck not so often as it should have done, when it struck eleven, and yet struck a while after too often when it struck but two, because the first time it was midnight, and the second time it was but one of the clock; so to estimate, whether what is said have its due length, we are not so much to look, whether it be little, or much, as whether a man speak in the right time, and say neither more nor less than he should.

MEDITATION IX.

Upon comparing the clock and his watch.

THE occasion I had, *Sophronia*, to compare the clock and my watch, suggested to me this other reflection, that the dial-plate of the clock being I know not how many times larger than that of the watch, the circle, on which the hours were marked in the one, did by vast odds exceed the correspondent circle of the other: and yet, though the index of the clock had then past through a far greater quantity of space than that of the watch, this little index, being, when it was indeed midnight, arrived at the mark of the twelfth hour, when the greater index was come but to that of the eleventh, I justly concluded, that the watch did not only go truer, but more forward than the clock.

Thus in estimating men's lives, there is something else to be looked at than the mere duration of them; for there are some men, who having loitered and trifled away very many years in the world, have no other argument of their age, than the church-books or their grey-hairs; and as little do they indeed live, that waste a number of insignificant years in successive or perpetual diversions from the true business and end of life. These, and many other kind of persons, that consume much time to little purpose, may be said rather to have lasted long, than to have lived long: as the careless wanderer, who, instead of travelling, does nothing but stray from one wrong way to another, though he do so at midsummer, from morning to night, may be said to have been long on horse-back, but not to have performed a long journey: whereas

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he, that by thrifty husbanding his time, and industriously improving it, has early dispatched the business, for which he was sent into the world, needs not grey hairs, to be reputed to have lived long enough, and consequently longer than those, that wear grey-hairs, only because they were born many years before him. In a word, to one of those sort of men we may attribute a longer time, but to the other a longer life; (for even the Heathen could say, *Non est vivere, sed valere vita*) and within how narrow a compass forever a man's life be confined, if he have lived so long, as, before he comes to the end of life, he have reached the ends of living; the attainment of that measure of knowledge, and the practice of those graces and virtues, that fit a man to glorify God in this short life, and to be glorified by him in that which shall have no end.

MEDITATION X.

Upon a thief in a candle.

THE silence of the night, and my being unable to sleep, disposing me to have my attention very easily excited; I chanced to take notice, that the dim light of the candle, which the curtains were not drawn so close as to exclude every where out of the bed, was on a sudden considerably increased, and continued so long in that condition, that, for fear of some mischance, I put my head out of the bed to see, whence it was that this new and unexpected increase of light proceeded; but I quickly found, that it was from a thief (as they call it) in the candle, which by its irregular way of making the flame blaze, had melted down a good part of the tallow, and would have spoiled the rest, if I had not called to one of those, that watched with me, to rescue the remains by the removal of the thief. But I had scarce done this, when, I confess to you, *Sophronia*, I found my self invited to make some reflections upon what I had done, and to read my self a new lesson by the beams of this new light. For though this thief made the candle shine more strongly, and diffuse a much greater light than it did before; yet because it made a great and irregular waste of the candle, I ordered it to be taken away; and on this occasion methought I might justly make use of that saying of *Pharaoh's* forgetful butler, *I do remember my faults this day*: For though I find no great difficulty in abstaining from other kinds of intemperance, yet to that of studying, my friends, and especially my physicians, have often accused me of being too indulgent. Nor can I altogether deny, but that in mental exercises there can be exorbitancies, and excesses, I may have sometimes been guilty of them; and that the things, for which I think life valuable, being the satisfaction, that accrues from the improvement of knowledge, and the exercise of piety, I thought it allowable, if not commendable, to consume or hazard it for the attainment of those ends; and esteemed sickness more formidable for its unfitting me to learn, and to teach, than for its being attended with pain and danger; and looked upon what it made me forbear, as far more troublesome than whatever else it made me endure. But I find my body is a jade, and tires under my mind, and a few hours fixed contemplation does sensibly so spend my spirits, as to make me feel my self more weary than the riding post for twice as many hours has ever done. Wherefore, since, though the proper use of a candle be to consume it self, that it may give others light, I yet thought it fit to have the thief taken away, because, though it made the candle give more light, it would have wasted it too fast, and consequently made it expire too soon. I see not how I can resist their persuasions, that would have me husband better the little stock of strength nature has given me; and the rather, by a moderate expence of it, endeavour to make it shine longer, though but dimly, than consume it too fast, though for a while to keep up a blaze: I will therefore endeavour to learn
of

of this sickness, and of this accident, what the doctors hitherto could never teach me, and enjoin my self an abstinence, which to me is more uneasy, than if wine, or women, or other sensual pleasures were to be the objects of it; but if in so difficult an exercise of self-denial, I do not always perform what I am now persuaded to, it is like I shall easily forgive my self, for but a little hastening the end of my life to attain the ends of it.

MEDITATION XI.

Upon the being in danger of death.

I KNOW, that physicians are wont, after their master *Hippocrates*, to tell us, that fevers which intermit are devoid of danger. But though an ague, whilst it continues such, could not be a mortal disease; yet why may it not degenerate into such a one? And for my part, who take the prognosticks of physicians to be but guesses, not prophecies, and know how backward they are to bid us fear, till our condition leave them little hopes of us; I cannot but think that patient very ill advised, who thinks it not time to entertain thoughts of death, as long as his doctor allows him any hopes of life: for in case they should both be deceived, it would be much easier for the mistaken physician to save his credit, than for the unprepared sinner to save his soul.

WHEREFORE, *Sophronia*, finding my disease attended with unusual threatening symptoms, not knowing where they would end, I last night thought it fit to suppose they might end in death: and two things especially made me the more ready for such an entertainment of my thoughts.

ONE, That we can scarce be too careful and diligent in fitting our selves for the acting of a part well, that we can never act but once: for where the scripture tells us, *it is appointed for all men once to die*; it is immediately subjoined, *that after that comes judgement*; and if we die ill once, we shall never be allowed to die again, to see if we would die better the second time than we did the first: but as the wise man allegorically speaks, *Where the tree falls, there shall it lie*. So that the faults committed in this last and importantest of human actions, being irreparable, I think the only safe way is to imitate him, who, having said, *If a man die, shall he live again?* presently annexed by way of inference and resolution, *All the days of my appointed time will I wait till my change come*.

THE other consideration, that recommended to me the thoughts of the grave, was this, that we may be often solicitous to provide against many evils and dangers, that possibly may never reach us; and many endure, from the anxious fears of contingent mischiefs, that never will befall them, more torment, than the apprehended mischiefs themselves, though really suffered, would inflict. But death will sooner or later infallibly come, and never finally deceive our expectations; and therefore the forethoughts of it are an employment, which may prove, we know not how soon, of use, and will (however) prove of excellent advantage: the frequent meditation of the end of our lives, conducing so much to make us lead them well, that the expectation of death brings not less advantages to those that escape the grave, than those that descend into it.

SUCH like considerations, *Sophronia*, having put me upon the thoughts of death, I presume you may have some curiosity to know what these thoughts were; and therefore, though I have neither fitness, nor inclination to mention to you those, that almost every sober person would have upon a death-bed, as a man, and as a Christian, I will only take notice to you of those few, that were suggested to me, by the less

general circumstances of my condition. And I am the more willing to satisfy your curiosity now, because I have myself been very inquisitive on the like occasion: for the approach of death will (if any thing can) make men serious and considerate; being for good and all to go off the stage, they make a truer and sincerer judgment of the world they are ready to leave, and then have not the wonted partiality for the pleasures and profits of a life they are now abandoning. And as the mind looks with other eyes upon the world, when death is ready to shut those of the body; so men are then wont as well to speak their thoughts more frankly, as to have them better grounded: death stripping most men of their dissimulation, as well as of other things it makes them part with; and indeed it is then high time for the soul to put off her disguises, when she is ready to put off the very body it self.

ONE thing then, that I was considering, *Sophronia*, was, in how wretched a condition I should now be, if I had been of the same mind with the generality of those, who are of the same age with me: for these presume, that youth is as well made for pleasures as capable of them, and is not more a temptation to vanity, than an excuse for it. They imagine themselves to do a great matter, if, whilst youth lasts, they do so much as resolve to grow better when it is gone; and they think, that for a man to be otherwise than intentionally religious before his hair begin to change colour, were not only to lose the privileges of youth, but to incroach upon those of old age. But alas! how few are destroyed by that incurable disease, in comparison to those that die before they attain it? And how little comfort is it upon a death-bed, to think, that by the course of nature, a man might have lived longer, when that very thought might justly prove dismal to an unprepared man, by suggesting to him, that this early death may argue the measure of his iniquities exceeding great, and that this untimely end is not so much a debt due to nature, as a punishment of sin? All the fruition of these deluding pleasures of sin cannot countervail the horror, that a dying man's review of them will create, who not only sees himself upon the point of leaving them for ever, but of suffering for them as long. And on the contrary, the review of youthful pleasures declined for virtue's or religion's sake will afford a dying man far higher joys, than their fruition would ever have afforded him.

MEDITATION XII.

Upon the same subject.

AND one thing more there is, *Sophronia*, that I dare not conceal from you, how much cause soever I have to blush at the disclosing it; and it is, that I judge quite otherwise of a competent preparation for death now I am near it, than I did when I was in health. And therefore, if one, that, since his conscience was first thoroughly awakened, still resolved to be a Christian, and though he too often broke those good resolutions, never renounced them, but tripped and stumbled in the way to heaven, without quitting his purpose of continuing in it, finds a formidableness in the approach of death: how uncomfortable must that approach be to those, that have still run on in the ways of sin, without once so much as seriously intending to forsake them? A youth free from scandal, and sometimes productive of practices, that were somewhat more than negative piety, is not so frequent among those, that want not opportunities to enjoy the vanities and pleasures of the world, but that the charity of others being seconded by that great inward flatterer self-love, made me imagine, that I was in a condition fitter to wish for death, than to fear it. But now I come to look on death near at hand, and see beyond the grave, that is just under me, that bottomless gulph of eternity; methinks it is a very hard thing to be sufficiently prepared

prepared for a change, that will transmit us to the bar of an omniscient judge, to be there doomed to an endless state of infinite happiness or misery. There is no art of memory like a death-bed's review of one's life; sickness, and a nearer prospect of death, often makes a man remember those actions, wherein youth and jollity made him forget his duty; and those frivolous arguments, which when he was in health, and free from danger, were able to excuse him to his own indulgent thoughts, he himself will scarce now think valid enough to excuse him unto God, before whom, if the sinless angels cover their faces, sinful mortals may justly tremble to be brought to appear. When the approach of death makes the bodily eyes grow dim, those of the conscience are enabled to discern, that as to many of the pleas we formerly acquiesced in, it was the prevalence of our senses, that made us think them reason: and none of that jolly company, whose examples prevailed with us to join with them in a course of vanity, will stand by us at the bar to excuse the actions they tempted us to. And if they were there, they would be so far from being able to justify us, that they would be condemned themselves. It is true, *Sophronia*, if we consider death only as the conclusion of life, and a debt all men sooner or later pay to nature; not only a Christian, but a man, may entertain it without horror: but if one consider it as a change, that after having left his body to rot in the grave, will bring his soul to the tribunal of God, to answer the miscarriages of his whole past life, and receive there an unalterable sentence that will doom him to endless and inconceivable joys, or everlasting and inexpressible torments; I think it not inconsistent either with piety or courage, to look upon so great a change with something of commotion: and many, that would not fear to be put out of the world, will apprehend to be let into eternity.

MEDITATION XIII.

A further continuation.

ANOTHER thing, *Sophronia*, which my present state suggested to me, was a reflection on the great mistake of those, that think a death-bed the fittest and opportune place to begin repentance in: but sure these men are very little acquainted, either with the disadvantages of a dangerous sickness, or the nature of repentance. It is true, that sin and death do more easily frighten one, when they are looked on as both together; but I much doubt, whether the being frightened by hell be sufficient to give a man a well-grounded hope of heaven: for when we see sin and torment at one view, and so near one to another, it is not so easy to be sure, which of the two it is, that, as we presume, scares the sinner towards heaven. And surely repentance, which ought to be the change of the whole man, and in some sense the work of the whole life, is very improperly begun, when men have finished that course, which it should have guided them in: nor have men cause to presume, that when God is severely punishing them for their sins, he will vouchsafe them so great a grace as that of repentance, which they would none of, till it could not make them serviceable to him. And as for the opportunity, it is hoped an expiring state may give men for repentance, they must needs be great strangers to great sicknesses, that can promise themselves so unlikely a matter. Who can secure them, that the acuteness of the disease will not invade the brain? And as deliriums and phrensies are not unfrequent in fevers, and other acute diseases; so in case they happen to persevere, the wretched patient is cast into a desperate condition, even on this side the grave, and as near as the body is to its dissolution, the man may be dead a pretty while before it.

BUT supposing he escape these accidents, which make repentance impossible, a dangerous sickness has other circumstances enough to make it very uneasy: for the organical faculties of the mind cannot but be dulled and prejudiced by the discomposure of the spirits, by which their functions are to be exercised; and the sense of pain, the troublesome prescriptions of physicians, the loathsome and bitter potions, the weakening operation of physick, the languishments produced by want of spirits, the restlessness proceeding from heat and want of sleep, the distracting importunity of those interested persons, especially if any of them be suspected to hover about the dying man's bed, as birds of prey, that wait for a carcase; the sighs and tears of friends and relations, that come to take their last farewell, and to imbitter it; the lawyer, that must be directed to draw up the will; the divine, that must be allowed to say something concerning the soul; and the affrighted conscience, that alone brings more disquiet than all the rest put together; do make a dying man's condition so amazing, so dismal, and so distracting, that to think this an opportune time to begin such a work, (which may well enough employ the whole man in his calmest state of mind) is a madness as great as any, that even a death-bed can, by the translation of the humours into the brain, occasion. For my part, I think it so wild, and so unadvisable a thing to put off the beginning to provide all graces to a death-bed, that I think it uneasy enough so much as to exercise *then* those that were acquired *before*; men being in that state commonly unable so much as to reap the consolation they have been sowing all along a pious life.

AND this, *Sophronia*, brings into my mind a consideration, which being taken from the very nature of a death-bed repentance, should, methinks, very much deter men from resolving beforehand to rely on it; and it is this, that granting those (Socinians, and others) to be mistaken, that think so late a repentance to come too late to be available; yet the dying sinner, though he may be kept from despair of passing to heaven, can scarce in an ordinary way have a comfortable assurance of getting thither; for though it be said, that a true repentance cannot come too late, yet it is a hard thing to be certain, that so late a repentance is true. Since repentance confessedly importeth an abandoning and renouncing of sin, at least in hearty purpose and resolution; it is very difficult for an habitual sinner, that remembers what vows and purposes of change of life, sicknesses or dangers have formerly induced him to make, which were forgotten, or violated, when the apprehensions that occasioned them were over; it is hard, I say, for such a one to be sure, that his present repentance is not of the same ignoble and uncurrent kind, since he has no experience to satisfy him, that it would be ordinarily, though not constantly, prevalent over the opposite temptations; and since also (which is mainly to be considered) it is so easy for a man to mistake for the true hatred of sin, and the love of God, a horror of sin springing from the present painful sense of the mischief procured by it, together with the great fear of the approaching torments that it threatens, and a strong desire of going to heaven, when seeing himself unable to stay any longer on earth, he must get thither to escape hell. And as it is thus difficult, when a man already feels much punishment for sin, and sees himself in danger of more, to discern clearly upon what account it is, that he is sorry for what he has committed; so it must be certainly a state unspeakably anxious and uncomfortable to find one's self dragged to the grave, without knowing, whether the last trumpet shall call him thence to heaven, or to hell. And if he should be deceived in judging of the validity of his repentance, the fatal error would be remediless, and the mistake far sadder and more horrid than that of the Syrians, who, when they thought they were arrived victorious at *Dothan*, found themselves at the mercy of their enemies in *Samaria*, 2 Kings vi. 18. To conclude, *Sophronia*, he, that resolves

not to renounce his sins, till he thinks Christ ready to renounce him for them, may very probably lose his soul, and has most certainly lost his ingenuity; and that will appear a very sad loss for a man, that being by death denied the opportunities of actually leading a new and pious life, must derive his comfort from the assurance, that he sincerely intends it.

MEDITATION XIV.

Upon the apprehensions of a relapse.

I HAVE now at length, *Sophronia*, by the goodness of God, regained that measure of health, which makes the doctor allow me to return to my former studies, and recreations, and diet; and in a word, to my wonted course of life: so that the physician having dismissed himself, nothing seems more seasonable and pertinent to my present condition, than that of our Saviour to the paralytick man, to whom he gave both recovery, and an admonition, which, if he obeyed, he found the more advantageous of the two; *Behold, thou art made whole; sin no more, lest a worse thing come unto thee.* But I am not so free from the apprehensions of an ague, as my friends think me from the danger of it: for having sadly experienced the uneasiness of sickness, I am thereby brought, though at no easy rate, to set a high value upon health, and be a very jealous preserver of so great a blessing; and those petty chilnesses, that formerly I regarded not, but was apt to impute to nothing but fumes of the spleen, or melancholy vapours, are now able to give me hot alarms, and make me apt to fancy them the fore-runners, if not the beginners, of the cold fit of an ague, the first invasion of that disease having been preceded by the like distempers; and accordingly, I carefully avoid the least irregularities in point of diet, or of any other kind, that may any ways endanger a relapse into the disease, that once handled me so ill. But why should I be more apprehensive for my body than my mind? and if at any time (as it may but too often happen) any sin should come to be prevalent in my mind, why should I not be solicitously afraid of all the occasions and approaches of it, and tremble at these commotions of the appetite, which would not else perhaps be formidable to me, in case I have found that such beginnings indulged or neglected have ended in actual sin, the real disease of the soul? And as dangerous sicknesses do for the most part leave a crazy disposition behind them, which threatens relapses; so sins once prevalent, though afterwards suppressed, do yet leave behind them a secret disposition or propensity to the reception of the same faults. And as it is less difficult to find examples of bodily diseases, than of spiritual ones, where the patient is protected from relapses; so I think we should be more watchful against falling back into the sins, than into the sicknesses, we have once found our selves subject to, unless we should think, that a greater danger, and of a nobler part, deserved less of our care.

MEDITATION XV.

Upon his reviewing and tacking together the several bills, filed up in the apothecary's shop.

EITHER my curiosity, *Sophronia*, or my value of health, has made it my custom, when I have passed through a course of physick, to review the particulars it consisted of; that taking notice by what remedies I found most good, and by what, little or none; if I should fall into the like distemper for the future, I might derive some advantage from my past experience. In compliance with this custom, as I was this day reviewing and putting together the doctor's several prescriptions.

tions sent me back by the apothecary; Good God! said I, in my self, what a multitude of unpleasant medicines have I been ordered to take! the very numbering, and reading them, were able to discompose me, and make me almost sick, though the taking of them helped to make me well. And certainly, if when I was about to enter into a course of physick, all these loathsome medicines, and uneasy prescriptions, had been presented to me together, as things I must take, and comply with, I should have utterly despaired of a recovery, that must be so obtained, and should not perhaps have undertaken so difficult and tedious a work, out of an apprehension, that it would prove impossible for me to go thorough with it. Thus when a man considers the duties, and the mortifications, that are requisite to a recovery out of a state of sin into a state of grace, he must be resolute enough, if he be not deterred from undertaking the conditions, that piety requires, by so many and great difficulties, as will present themselves to his affrighted imagination. But let not this make him despondent; for it is true, that these discomposing medicines, if I must have taken so much as a tenth part of them in one day, would have either dispatched me, or disabled me to endure the taking any the next. But then, although I now see these troublesome prescriptions all at once, I did not use them so, but took only one or two harsh remedies in one day, and thereby was enabled to bear them, especially being assisted by moderate intervals of respite, and supported both by other seasonable cordials, and by that highest cordial, the hope, that the use of these troublesome means of recovery would soon free me from the need of them. And thus, though the hardships of piety are, by the ghostly and carnal enemies of it, wont to be represented to one that begins to grow a convert, so great and formidable a multitude as to be insuperable; yet if he considers, that though his foresight meet with them all at once, yet he will need to grapple with them but one after another, and may be as well able to overcome a temptation this day, or to-morrow, as he did another yesterday: so that to this case also may in some sense be applied that (either counsel, or precept) of our Saviour, not to be solicitous for to-morrow, but to charge no more upon a day than the trouble that belongs to it. And if he considers too, that as a wise physician has always a great care, that his remedies be not disproportionate to the patient's strength, and after harsh physick to relieve him with cordials; so God will not suffer those, that intrust themselves to him, to be tempted above what they are able, but will allow them cordials after their sufferings, in case he do not turn the sufferings themselves into cordials. If, I say, our new convert shall consider things of this nature, he will not be much discouraged by the appearance of difficulties, that will as much ennoble and indear his success, as they can oppose it; and he will never despair of victory in an engagement, where he may justly hope to have God for his second, and heaven for his reward.

OCCASIONAL REFLECTIONS.

S E C T. III.

R E F L E C T I O N I.

Upon the sight of some variously-coloured clouds.

THERE is amongst us a sort of vain and flanting grandees, who for their own unhappiness, and their age's, do but too much resemble these painted clouds; for both the one and the other are elevated to a station, that makes most men look upon them, as far above them; and their conspicuousness is often increased by the bright sunshine of the prince's favour, which, though it really leaves them creatures of the same frail nature, that it found them of, does yet give them a lustre and a gaudiness, that much attracts the eye, and perhaps the envy and respect of those superficial gazers upon things, that are wont to be amused, if not dazzled, with their insignificant outshines. But the parallel holds further; for as, in spite of these clouds' sublimity and conspicuousness, they are but airy and unsolid things, consisting of vapours, and steered by every wind: so the fine people I am comparing them to, in spite of their exaltation, and of all the shew they make, are really but slight persons, destitute of intrinsic and solid worth, and guided either by their own blind lusts and passions, or else by interests as fickle as those, (to which it will be no addition to say) or as variable as the wind. And as these clouds, though they seem vast as well as high, and are perhaps able, for a while, to make the sky somewhat dark, have usually but a short duration, and either quickly fall down in rain, or are quite dissipated, and made to disappear; so those titled persons, what shew soever their greatness makes, do oftentimes, either by a voluntary humility and repentance, as it were, descend of their own accord, and, by doing of good, endeavour to expiate and make amends for their former uselessness, if not mischiefs; or else, after having been a while stared at, they do (some of them more slowly, and some more abruptly) vanish, without leaving behind them any thing that can so much as entertain our sight in the very place, where before they engrossed it: and this ruin sometimes happens to the most elevated persons, from that very prince, whose favour made them attract so many eyes; as clouds are oftentimes dispersed before night by the same sun, that had raised and gilded them in the morning.

R E F L E C T I O N II.

Upon his making of a fire.

HOW many fruitless blasts have I been spending upon this sullen fire! It was not, though, the greenness of this wood, that made it so uneasy to be kindled; but, it was alone the greatness of the logs, on which the fire could take no hold, but by the intervention of such smaller sticks as were at first wanting here: witness, that I had no sooner laid on a little brushwood, but the flame from those kindled twigs, invading and prevailing on the billets, grew suddenly great enough to threaten to make the house it self part of its fuel, and turn it to such ashes, as it makes haste to reduce the wood into. Methinks the blaze of this fire should light me to discern something instructive in it: these blocks may represent our necessary; these sticks our
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less important, religious practices; and this aspiring flame, the subtle inhabitant of that of hell. It will be but successlessly, that the devil can attempt our grand resolves, till he have first mastered our less considerable ones; and made his successes against these, not only degrees, but instruments, in the destroying of the other: our more neglected and seemingly trivial affections, having once received his fiery impressions, do easily impart them to higher faculties, and serve to kindle solidier materials. It is therefore the safest way, to be faithful even to our lesser determinations, and watchful over our less predominant passions; and whensoever we find our selves tempted to violate the former, or neglect the latter, not so barely to cast one eye upon the seeming inconsiderableness of what we are inticed to, as not to fix the other upon the consequences that may attend it; and therein, to consider the importance of what such slighted things may, as they are managed, prove instrumental, either to endanger, or to preserve.

REFLECTION III.

Upon my spaniel's carefulness not to lose me in a strange place.

DURING my stay at home, whilst every body this cur chanced to meet, made so much of their landlord's spaniel, that they seemed to have added to oracles that proverb of *Love me, love my dog*, the cajolled cur would never keep at home; but being welcomed to so many places abroad, made me few visits, that cost me not the trouble of sending for him. But now, that we are in a place, where he sees no more men than strangers, he stirs not from my heels, and waits so close, and carefully, that it were now more difficult to lose him, than it was formerly to keep him from wandering. Thus doth it generally fare with us; whilst we are environed with numerous outward objects, which, smiling on us, give our gaddings to them, the temptation of an inviting welcome; how inclined are we to forget and wander from our great master? But when we are deprived of those inveigling courtiers, our Maker too is freed from those seducing rivals, and our undistracted affections are brought to settle on their noblest object, by the removal, and the displacing, as well as they would be by the knowledge and the undervaluation, of inferiour ones. Lord! when I lose a friend, or any outward idol of my fondness, teach me to reduce him to leave thee his heir, by taking that loss for a summons, to transfer and settle my whole love on thee: and if thou but vouchsafe to make me so happy, I shall think my self enough so, not to envy him, to whom the loss of his asses proved an occasion of his finding a crown; and shall not so much regret what thy dispensations shall have taken from me, as gratulate to my self their having reduced me unto thee.

REFLECTION IV.

Upon the prodigiously wet weather, which happened the summer that Colchester was besieged. (1648.)

HOW strangely unseasonable is this melancholy weather! and how tedious a winter have we endured this summer? More than these few last weeks have not afforded us half as many days, wherein we were neither troubled with showery, or threatened by cloudy weather; and we in *England* have great temptations to envy nature's kindness unto *Rhodes**, if it be true what geographers relate of that island,

* At *Rhodes* the air is never so dim and cloudy, but one hour or other the sun shineth out. *Pliny*, l. 2. c. 62. Where he also says the same of *Syracusa*.

that it is a rarity for the inhabitants to see a day pass without their seeing the sun : for, among us, the confusions of our country seem to have infected our very air, and serenity is as great a rarity in the sky, as in men's consciences ; so that those, who are wont to make fires, not against winter, but against cold, have generally displaced the florid, and the verdant ornaments of their chimneys, and think *Vulcan* more proper there than *Flora* ; and some begin to doubt, whether our almanacks be not mistaken, by calling this month *July* instead of *November*. But notwithstanding all this appearance of winter above our heads, yet whilst we see, that cherries and strawberries, and other summer fruits, do grow, and, though but slowly, make a progress towards maturity in our orchards, we doubt not that it is summer, and expect, that these fruits, though they will not be early ones, will at length come to be ripe ones.

THUS, for reasons, which, though we know not yet, our knowing of God may assure us to be both wise, and just, a pious soul may sometimes be reduced to so sad a condition, that the face of heaven does to her appear perpetually overcast ; and the tokens of God's displeasure do so closely follow one another, that, to borrow *Solomon's* phrase, *The clouds return after the rain*. But if, notwithstanding all this, the seemingly deserted soul, do, like the good ground mentioned in the gospel, bring forth fruit with perseverance ; if prayer, charity, resignation, and those other divine graces, that are wont to be the proper and genuine productions of God's spirit, do flourish, and prosper in the soul, we may safely conclude that soul, though never so disconsolate, to be in the state of grace, and that she really receives the blest assistances of him, who can alone give the increase (to the seeds of piety and virtue) though not in the glad and conspicuous way of an unclouded heaven, yet in the effectual, though secret, method of fructifying influences ; and we may reasonably hope, that he, that has not only begun a good work, but carried it on thorough such impediments, and disadvantages, will perfect it, by bringing the slow, but yet gradually, ripening fruit to the due perfection : for those, that are the humble Christian's proper graces, do so much depend upon the author, that, if they flourish, his hiding himself in clouds need not make us doubt the fruits we see, to be the productions of the Sun of righteousness, though we see him not. We must not hastily conclude it winter with the soul, though the heaven be lowering, provided the earth be fruitful ; but remember, that the saving influence of God's spirit may be, where his comfortable presence is not perceived : the living in sensible comforts and joys is rather a part of our reward, than of our duty ; and that (consequently) it may save many modest and pious persons a great deal of disquiet, if they would learn to judge of their spiritual condition, rather by the duties, and services, they pay God, than by the present consolations he vouchsafes them ; or, in a word, rather by what they do, than by what they feel.

REFLECTION V.

Upon his being carved to at a feast.

THOROUGH many hands hath this plate passed, before it came to mine ; and yet, though I bowed to every one of those that helped to convey it, I kept my chief and solemnest acknowledgment for the fair lady that sent it. Why shouldest thou not, O my soul, instruct thy gratitude to tread in the steps of thy civility ? When thou receivest any blessing from *that Father of lights, from whom every good and perfect gift comes down*, pay a fitting share of thy thanks to them, that hand it to thee ; but thorough all those means, look principally to that God, that

sends it. Let not the pipe usurp upon the spring, (that were as absurd, as it were for me to kiss my hand to the plate, or at best, to those that helped to convey it, with a neglect of the lady) but so pay thy due acknowledgments to the reachers, that thou be sure to reserve thy principal thanks, and highest strains of gratitude, for the giver.

REFLECTION VI.

Upon the sight of a looking-glass, with a rich frame.

EUGENIUS, LINDAMOR, EUSEBIUS.

Lind. THIS glass has a frame so curious, and so rich, that though I could scarce, if I would, withhold my eyes from gazing here; yet, I believe, the operation it has on my curiosity, is no more than what it generally has on that of others; and by the attention, with which I saw, even you, gentlemen, survey it, I am easily persuaded, that one needs not be a lady, not to pass by such a looking-glass without repairing to it.

Eug. I AM much of your opinion, *Lindamor*; and such a sight as this has often made me a greater friend, than many severer persons are, to eloquence in sermons: for as if this very glass had been placed here in a mean or common frame, it would scarce have stopped us in our passage through the room, or have invited us to consult it; so a sermon may, by the nicer sort of auditors, be left unregarded, though it be for substance excellent: when as the frame, though it be not part of the glass, nor shews us any part of our faces, does yet, by its curious workmanship, attract our eyes, and so invite us to consult the glass, that is held forth in it; so the wit, and fine language, wherein it is dressed up, though it be no essential or theological part of the sermon, yet it is often that, which invites men to hear, or read it.

Lind. I THINK indeed, *Eugenius*, that wit and eloquence do highly recommend sermons, and devout composures, to the curiosity and attention of some, that else would scarcely mind them; and upon that account, I allow of your comparison: but give me leave to carry it on a little further, by observing, that as the curious frame doth as well please, as attract, the eye, without representing to it the lively image of the beholder's face; so the fine expressions you applaud, are commonly parts of a sermon, that have no specular virtue in them; I mean, that have no power, like a good looking-glass, to acquaint the beholder with the true image or representation of his own complexion, and features: nor will this gaudy frame shew him what is otherwise than it should be; the discovery of which, nevertheless, in order to the rectifying what is amiss, is the principal and genuine use of a looking-glass. And therefore, as no skilful man will judge of the goodness of a glass, by the fineness of the frame, but rather by its giving him a true representation of his face, without liking it the worse, for shewing him its moles, and warts, or other blemishes, if it have any; so no wise Christian will judge of a rousing sermon, rather by the language, than the divinity, or will think the worse of a good book, for discovering his faults, or making him think the worse of his own, or other men's ill courses.

Euseb. LET me add, gentlemen, that as when a glass has a rich and gaudy frame, children's eyes are oftentimes so entertained and amused with it, that they are regardless of any thing else; and for the sake of that part, which they can but see, they are unmindful to consult that usefuller part, whose office it is to discover to them, them-

selves:

selves: so, when there is too much of rhetorick in a sermon, many, that should not be children, have attention, not only so attracted, but so detained, by that, that they are not thereby invited to consult, but diverted from regarding, the more instructive part of the discourse. And the more witty and critical sort of auditors, are so much more accustomed to judge of sermons, than to judge of themselves by them, that they deal with them, as if, in this glass, a man should only praise or discommend the workmanship of the imbossed images of the frame, without caring to make use of the glass itself, to mend any thing he finds out of order about him. For thus, these fastidious and censorious hearers make no other use nor repetition of sermons, than to censure or applaud the expressions, and contrivances, (which should be looked upon but as the ornaments of it) without minding the doctrine, or caring to amend what that has discovered to be amiss in them. But it must be confessed, though I must grieve and blush, it can be truly so, that it is but too often, as the scripture somewhere complains, *like people, like priest*; and that there is a sort of preachers, and those of the most celebrated, who take a course more likely to encourage, than reform, such hearers; and which would, perhaps, make men such, if it did not find them so: for one of this sort of preachers (for I am loth to call them divines) appears more solicitous to make his expressions, than to make his hearers; good. And whereas, these, that are concerned for the winning or the saving of the souls, think it a less sure sign of a good sermon, that it makes the hearers applaud the preacher, than that it makes them condemn themselves; the orator I am mentioning, had much rather hear their praises than their sighs; and, accordingly, is more solicitous to tickle their ears, than, how much need soever there be of it, to lance their consciences. He may, with far more truth than piety, invert the profession of St. Paul, and say, that he preaches *not Christ crucified, but himself*; and though now and then he seem very vehemently to declaim against vices, yet one may easily enough perceive, that it is but a personated anger, and that he rather fences with sin, than is concerned to destroy it, and speaks against it rather to shew skill, than to exercise hatred: and as he affects to appear rather an orator than a divine, so he is well enough content his auditors should rather admire his good language than follow his best counsel; and, as if all that belongs to ministers, and their flocks, could be performed in the pulpit, and the pew, he is more careful to remember his sermons before he has delivered them, than to keep his auditors from forgetting them afterwards; and unconcerned for their proficiency, seeks but their praises, scarce ever aiming at so much as his own discharge. In a word, in such kind of sermons, there is little spoken, either from the heart, or to the heart; the orator and the auditory tacitly agreeing to deceive themselves; and the conversion of sinners being neither the effect, nor the aim of such florid, but unedifying discourses, the business is transacted on both sides, as if the preacher thought he had done his part, when he had shewn his wit, and the hearers thought they had done theirs, when they have commended it.

REFLECTION VII.

Upon my spaniel's fetching me my glove.

POOR cur! how importunate is he to be employed about bringing me this glove? and with what clamours, and how many fawnings, does he court me to fling it him? I never saw him so eager for a piece of meat, as I find him for a glove: and yet he knows it is no food for him, nor is it hunger, that creates his longings for it; for now I have cast it him, he does nothing with it, but (with a kind of pride to be

sent for it, and a satisfaction, which his glad gestures make appear so great, that the very use of speech would not enable him to express it better) brings it me back again; as he meant to shew me, he desired not to keep it for himself, but only to have it in his power to return it as a present to his master. But he must not bring me thus an empty glove; it is in thee, my soul, to fill this accident with instruction, by learning from religion as disinterested a behaviour towards God, as nature taught this brute creature towards me. I will, in my addresseees for externals, less earnestly implore them for the service they may do me, than for the service I may do God with them; and (as princes commands are looked upon by courtiers as honours, and as favours) contenting myself with the satisfaction of being trusted, and employed by him, I will rejoice at the liberal expressions of his love, as they may be improved into proportionable expressions of mine, and will beg no largesse of his bounty, without a design of referring it to his glory.

REFLECTION VIII.

Upon the taking up his horses from grass, and giving them oats before they were to be ridden a journey.

JUST so does God usually deal with his servants: when he vouchsafes them extraordinary measures of grace, they are to look for employments that will exercise it, or temptations that will try it.

Thus that great *captain of our salvation*, Heb. xii. 2. whom the scripture so much and so deservedly exhorts us to have our eyes on, when at his solemn inauguration into his prophetick office, the heavens were opened, from whence the spirit of God did in a bodily shape descend like a dove upon him, accompanied with a heavenly voice, proclaiming him the beloved son of God, *in whom the Father is well pleased*, *Mark i. 12.* *Matth. iv.* Then, I say, that is, (as St. Mark tells us) *immediately* Jesus (being, as another evangelist has it, *full of the Holy Ghost*, Luke vi. 1.) was led up of the spirit into the wilderness to be tempted of the devil. That wise and merciful disposer of all things, who will not suffer his children to be tempted above what they are able, seasonably fortifies them by these preparatory provisions and consolations, for the labours and difficulties they are to be exposed to. But whereas, if these horses had reason wherewith to foresee the journey in order whereunto the provender is so plentifully given them, they would (if not be troubled at their good cheer) at least lose much of the pleasure of it, by thinking of the labour to ensue: With the servants of God the case is much otherwise; for such is his goodness to those he is pleased thus to deal with, in proposing and reserving them a crown in some sort proportionate to, and yet inestimably outvaluing, the toils and difficulties requisite to obtain it; that as advantageous and as welcome as his preparatory vouchsafements can be, the pious soul may well think them less favours upon their own account, than as they enable the receiver to do the more service to the giver.

REFLECTION IX.

Upon the making of a fire with charcoal.

THOSE that lust fascinates are apt to imagine, that if they can suppress its visible effects, and sensible heat, that will be sufficient to free them from all the mischiefs, they need fear from it: but lust is so pernicious a guest, that not only he is very watchful to intrude again where he has once been entertained, but, notwithstanding

standing his absence, he may continue to do mischief to those, that seem to have quite expelled him. For as wood, that is once thoroughly set on fire, may afterwards have that fire quite choaked, and extinguished, and yet by those changes be turned into charcoal, whereby it is not only made black, but disposed to be far more easily kindled, and consumed than before; so those, who have once had their hearts thoroughly possessed by the pernicious flames of lust, (which is indeed, to imply an inspired expression, *to be set on fire of hell*) even when they have stifled these criminal flames, and feel no more of their heat, may not only have their reputation irrecoverably blemished by what is past, but commonly carry about with them an unhappy disposition to be re-inflamed, and to have by a few sparks, and a little blowing, those destructive fires so re-kindled, as to rage more fatally than ever.

REFLECTION X.

Looking through a prismatical or triangular glass.

THIS more than flattering glass adorns all the objects I look on through it, with a variety of colours, whose vividness does as much charm my sense, as their nature poses my reason; without the help of the sun, and clouds, it affords me as many rainbows as I please. And not only when I look on trees, and meadows, and gardens, and such other objects, that are of themselves acceptable to the sight; this glass lends them ornaments above any they are beholden for either to nature, or art: but when I cast my eyes upon coarser, and homely things, and even on dunghills, this favourable interposer presents them to me in such curious and gaudy colours, that it does not so properly hide their deformities, as to make them appear lovely. So that which way soever I turn my eyes, I find them saluted, as if I were in some rich jeweller's shop, with sapphires, topazes, emeralds, and other Orient gems, the vividness of whose colours may justify those, that think colours to be but disguised light, which, by these various reflections, and refractions, comes to be rather dyed than stained.

BUT this glass must as well afford me instruction, as delight, and even by deceiving me, teach me: for thus sinful Christians, when God looks upon them in themselves, must needs seem too polluted, and disfigured, not to appear loathsome to him, *who is of purer eyes than to behold iniquity* without abhorrency; but when Christ interposes betwixt his eyes and us, we then seem far other things than otherwise we should, and not only we do not appear filthy, but we do appear lovely, if not glorious. And as though some objects, as things purely white, and flames, look better through this glass, than homely and dirty ones; yet even these, looked upon through this glass, are more richly adorned, than the others beheld without it: so, whatever difference there may be betwixt persons, that are either innocent, or exemplary, upon the bare account of morality; and those ignorant or frail children of God, that, in themselves considered, would be much inferior to those newly mentioned; yet when these are looked upon through Christ, they are much more acceptable in God's eyes, than the others considered out of him. And I shall add this further, that whereas my looking upon objects through the prism, however it makes them appear to my eyes, does work no real change in the things themselves, but leaves those, that were homely and foul before, foul and homely still; God's gracious looking upon us in Christ makes us by degrees become fit for his goodness to take delight in, and has an improving and transfiguring power on us; like the sun, that cherishes green and unblown flowers, and paints them with their curiosest colours, by his looking on them. Since then the Scripture tells us, that we are not only reconciled to God, but, if I may so express it,

it, are *ingratiated and endeared to him in the beloved*; how much do we owe to that blessed Saviour, upon whose account we enjoy the invaluable privilege to appear (and grow fit to do so) pleasing in God's eyes? which, besides that it is the highest honour, leads to the highest happiness; or rather, is the one as well as the other.

An Advertisement touching the Fourth Section.

A READER, that is not unattentive, may easily collect from what he will meet with in some of the ensuing discourses, that they were written several years ago, under an usurping government, that then prevailed. And this may keep it from appearing strange, that in papers, which contain some things not likely to be relished by those, that were then in power, the author should take occasion to speak of himself as of another person; as well to avoid the being suspected by them, in case his papers should come into any of their hands, as to comply with the design he then had; that if these discourses should happen to be made publick, the reader might be left to guess, whether or no he were entertained with a fiction, or a true narrative. And though a change of circumstances has occasioned the publication of these papers, which should have come forth by themselves (if at all) in such a way as will make most readers look upon them as containing a story purely romantick; yet they may have in them much less of fiction, than such will (it is like) imagine. For being really a great lover of angling, and frequently diverting my self at that sport, sometimes alone, and sometimes in company; the accidents of that recreation were the true themes, on which the following discourses were not the only meditations I had made. Nor is the intimation given at the end of this (fourth) section, of a further continuation of such discourses, an artifice or shift, to steal away from a conversation I was unable to continue, without seeming to do so; there being in readiness divers reflections relating to our anglers, which had furnished *Eusebius* and his friends with discourses for the afternoon, if I had judged, that to invite an addition to so prolix an account as I had given of them already, nothing could be requisite but a supply of thoughts.

OCCASIONAL REFLECTIONS.

S E C T. IV.

Which treats of Angling improved to spiritual uses.

DISCOURSE I.

Upon the being called upon to rise early on a very fair morning.

THE sun had as yet but approached the east, and my body as yet lay moveless in the bed, whilst my roving thoughts were in various dreams, rambling to distant places; when, methought, I heard my name several times pronounced by a not unknown voice. This noise made me, as I was soon after told, half open my eyes, to see who it was that made it, but so faintly, that I had quickly let my self fall asleep again, if the same party had not the second time called me louder than before, and added to his voice the pulling me by the arm. But though this waked me so far, as to make me take notice, that I was called upon to rise, yet my drowsiness, and my unwillingness to forgo a not unpleasant dream, keeping me from discerning distinctly, who it was, that called me, made me briskly enough bid him, whatever his business were, let me alone: but though at the same time I turned away my head to shun the light, though dim, which at the half-opened curtain shone in upon me, yet the party, instead of complying with my desires, did by the throwing open the curtains, further let in so much more light upon my face, that finding it would not serve my turn to keep my eyes shut, I opened them to see, who it was, that gave me this unwelcome disturbance. This I had no sooner done, than that I perceived that it was *Eusebius*, who with *Lindamor*, and two or three other friends, was come to call me to go a fishing, to a place, where by appointment we were to meet about sun-rising. The respect I paid *Eusebius*, and the value I placed upon his conversation, covered me with blushes to be thus surprized by him; and obliged me to satisfy him as well as I could, how much I was troubled and ashamed to have the favour of his company brought me to my bed-side, when I ought, and intended to have waited on him. And thus, whilst I was making him my apologies, and he was pleasantly reproaching me for my laziness, and laughing at the disorder I had not yet got quite out of, I made a shift hastily to get on my clothes, and put my self into a condition of attending him and the company to the river-side.

WHILST we were walking thither-ward, and *Lindamor* was minding *Eusebius* of the promise he had made the day before, to exercise, upon most of the things that should occur to us, his art of making occasional reflections, I was delighting my self with the deliciousness of that promising morning, and indeed the freshness of the air, the verdure of the fields and trees, and the various enamel of the meadows, the musick of the numerous birds, that with as melodious as chearful voices welcomed so fair a morning; the curious orient colours, wherewith the rising sun embellished the eastern part of the sky, and above all that source of light, who, though he shews us all, that we see of glorious and fair, shews us nothing so fair and glorious as himself, did so charm and transport me, that I could not hold expressing my satisfaction in terms, that, *Eugenius* was pleased to say, needed not rhymes to make them poetical. And the sense of this invited me to add, that I now would not for any thing have missed being
waked,

waked, and thought my self hugely obliged to *Eusebius's* freedom, that would not suffer me to sleep out so glorious a morning, nor lose the satisfaction of such desirable company.

Eusebius, who was but a little way off in discourse with *Lindamor*, over-hearing a good part of what I had said, thought fit to take thence a rise, to begin complying with his friends requests; and accordingly, walking up towards me, and addressing himself to me, he told me, You are unconcerned enough, *Philaretus*, in what I am about to say, to make it allowable for me to tell *Lindamor*, that what has this morning happened to you, puts me in mind of what I have several times observed on another occasion. For when a man is so lulled asleep by sensual pleasures, that, like one that sleeps, he has but the faculty, not the exercise of reason, and takes his dreams for realities; if some serious divine, or other devout friend, concerned for the sinner's soul, or his glory, that died to redeem it, endeavour to awaken him, and rouse him out of that state, wherein he lies so much at ease; such attempts are wont at first to be looked upon by the lazy sinner, enamoured of his ease, and present condition, but as pieces of unseasonable, if not uncivil officiousness; and entertaining the light it self but as an unwelcome guest, he obstinately shuts his eyes against that, which alone makes them useful; and, instead of looking upon the attempter as his friend, he checks him, and expostulates with him, and uses him almost as an enemy: inso-much, that too often those, that love the welfare of souls too little, or their own ease too much, forego, with their hopes, their endeavours to reclaim him. But if, by God's blessing, upon the constancy of this kindness, and the letting in of so much light upon the sinner, that he finds himself unable to continue his slumber any longer with it, he comes to be thoroughly awaked, he quickly grows sensible, that he is brought out of the kingdom of darkness, into a true and marvellous light; and, instead of those empty fleeting dreams, which did before amuse and delude him, and which, to relish, and be fond of, the eyes of his mind must be as well closed, as those of his body, he is admitted to noble, and manly entertainments, such as reason chuses, conscience applauds, and God himself approves. And this change of his condition he finds so advantageous, that he would not, for all the world, return again to that, he was at first so angry to be dissuaded from; and he does not forgive, but thank the person, that disquieted him, and blushes at the remembrance of his having reduced others to importune him to be happy: and, betwixt shame and gratitude, the sense of his present, and of his past condition, possessing him, how much he has reason, to make his rescuer as well amends for what he endured, as retributing for what he acted for him, he does, perchance, especially in the first fervors of his zeal, think himself as much obliged to his awakener, as *Philemon* was to *St. Paul*, to whom, the Scripture says, that he owed even himself. And sometimes such a new convert, as I am speaking of, will think his obligation, to the instrument of his change, so suitable to the transcendent satisfaction he finds in the change itself, that he would despair of seeing his benefactor sufficiently recompensed, if he did not remember a saying of the Prophet, (*That those, that turn others to righteousness, shall shine as the stars for ever and ever*) that gives him ground to hope, that God himself (whose plenty, as well as bounty, is inexhausted) will make the recompence his work. Wherefore, concludes *Eusebius*, if you chance to have any friends, (as it is odds most men have) that stand in need of this as great, as unwelcome, expression of kindness, let us not be too soon discouraged, by finding the effects of our friendship coldly received, and possibly too looked upon as disturbances; for besides, that the less they are desired, and the worse they are entertained, the more they are needed; a Christian is not bound, so much to concern himself in the success of his endeavours, as to leave

it in the power of every one that will be obstinate, to make him unhappy, when the business, one way or other, come to an end, he may miss his aim, without losing his labour, since he serves a master, that is as ready to reward, as able to discern intentions; and, in case your endeavours do succeed, you will at once make a man your friend, and worthy to be so. And you shall scarce ever find men more affectionate to you, than those you have made your friends by making them enemies to vice.

DISCOURSE II.

Upon the mounting, singing, and lighting of larks.

THE agreement we had made at our setting forth, that the motion of our tongues should not hinder that of our feet towards the river-side, was the cause, that the past discourses not having discontinued our walk, by that time they were ended, we began to traverse certain ploughed lands, that lay in the way betwixt us and the river. But we had scarce entered those fields, when our ears were saluted with the melodious musick of a good number of larks, whereof some mounted, by degrees, out of sight, and others, hovering and singing a while over our heads, soon after lighted on the ground, not far from our feet.

AFTER we had a while enjoyed this costless, and yet excellent musick, both *Eusebius* and I, chancing to cast our eyes towards *Eugenius*, observed, that his did very attentively wait upon the motions of a lark, that, singing all the way upwards, and mounting, by degrees, out of sight, not long after descended, and lighted among some clods of earth, which being of the colour of her body, made us quickly lose sight of her. Whereupon *Eusebius*, who was full as willing to hear as speak, and, in the occasional reflections that he made, was wont at least as much to aim at the exciting others thoughts, as the venting of his own, begged *Eugenius* to tell us what it might be, which his attentiveness to the motions of the lark made us presume he was thinking on.

Eugenius, after a little backwardness, which he thought modestly exacted of him, soon answered us in these terms:

AMONG all the birds, that we know, there is not any, that seems of so elevated, and, I had almost said, heavenly a nature as the lark; scarce any give so early and so sweet a welcome to the springing day. And that, which I was just now gazing on, seemed so pleased with the unclouded light, that she sung as if she came from the place she seemed to go to; and during this charming song, mounted so high, as if she meant not to stop, till she had reached that sun, whose beams so cherished and transported her; and in this aspiring flight she raised herself so high, that though I will not say, she left the earth beneath her very sight, yet I may say, that she soared quite out of ours. And yet when from this towering height she stooped to repose or solace herself upon the ground, or else when to seize upon some worthless worm, or other wretched prey, she lighted on the ground, she seemed so like the earth, that was about her, that I believe you could scarce discern her from its clods. And whereas other birds, that fly not half so high, nor seem any thing near so fond of the sun, do yet build their nests upon trees, the lark does as well build hers upon the ground, as look like a part of it.

THUS I have known, in these last and worst times, many a hypocrite, that when he was conversant about sublimer objects, appeared, as well as he called himself, a saint; nothing seemed so welcome to him as new light; one might think his lips had been touched with a coal from the altar, his mouth did so sweetly shew forth God's praise, and sacred dispensations. In sum, take this hypocrite in his fit of devotion,

and to hear him talk, you would think, that if he had not been already in heaven, at least he would never leave mounting till he should get thither.

BUT when the opportunities of advantaging his lower interests called him down to deal about secular affairs here below, none appeared more of a piece with the earth than he, for he looked, as if he had been besmeared all over with the earth round about him, and he seemed, in providing for his family, to be of a meaner and a lower spirit, than those very men, whom in discourse he was wont to undervalue, as being far more earthy than himself.

SINCE we know, says *Eusebius*, that the best things corrupted prove the worst, it can be no disparagement to piety, to acknowledge, that hypocrisy is a vice, which you cannot too much condemn. And when the pretending of religion grows to be a thing in request, many betake themselves to a form of religion, who deny the power of it; and some perchance have been preferred less for their *Jacob's* voice than for their *Esau's* hands.

BUT, *Eugenius*, let us not, to shun one extreme, fondly run into the other, and be afraid or ashamed to profess religion, because some hypocrites did but profess it: his course is ignoble, and preposterous, that treads the paths of piety, rather because they lead to preferment than to heaven; but yet it is more excusable to live free from scandal for an inferior end, than not to live so at all: and hypocrites can as little justify the profane, as themselves. It may be, that all, that own religion, are not pious; but it is certain, that he, that scorns to own it, must less be so. And if scoffers at piety should succeed the pretenders to it, they cannot be said (as sometimes they would be thought) to be an innocent sort of hypocrites, that are better than they seem: for scandal is a thing so criminal, and contagious, that whosoever desires, and endeavours to appear evil, is so: to refuse to be religious, because some have professed themselves to be so, is to injure God, because he has been injured. A skilful jeweller will not forbear giving great rates for necklaces of true pearl, though there be many counterfeits for one that is not so; nor are the right pearls a whit the less cordial to those, that take them, because the artificial pearls made at *Venice*, consisting of mercury and glass, for all their fair shew, are rather noxious, than medicinal. And indeed our knowledge, that there are hypocrites, ought rather to commend piety to us, than discredit it with us; since as none would take the pains to counterfeit pearls, if true ones were not of value; so men would not put themselves to the constraint of personating piety, if that it self were not a noble quality. Let us then, *Eugenius*, fly as far as you please from what we detest in hypocrites: but then let us consider, what it is that we detest; which being a bare, and therefore false pretence to religion, let us only shun such a pretence, which will be best done by becoming real possessors of the thing pretended to.

DISCOURSE III.

Upon the sight of a fair milk-maid singing to her cow.

EUGENIUS, who was not at all indisposed to listen to exhortations of this nature, not only embraced this made him by his friend, but with earnestness enough continued the conference to explain his meaning, and satisfy *Eusebius*, that he did not think piety fit to be discountenanced, though he thought hypocrisy was so; and that he was no enemy to the profession of religion, but to those, that blemished it by unsuitable practices. And with such kind of discourses we continued our walk, till being come to a stile, over which we were to pass out of one meadow into another, I chanced to stop, and turn about to pay *Lindamor* the respect of desiring him to lead

me the way over : but not finding him there, I hastily cast my eyes all over the field, till at length they discovered him a good way off, in a posture, that seemed extremely serious, and wherein he stood as immovable as a statue. This sight soon carried me towards him, and I had dispatched half my way, before his changing his posture gave him an opportunity to discover me ; which as soon as he did, he immediately came to meet me, and almost before I had asked him the occasion of what I had seen, Whilst (replied he) *Eugenius* was purging himself from a fault, that none that knows him will suspect him to be guilty of ; I was detained a little behind you by the musick of one of those larks, whose melody was so charming, that I could not find in my heart to make haste from it : but whilst I was listening to it, my attention was diverted by a nobler object ; for I heard from the further corner of this meadow, a voice, which, though not governed with skill, did so repair the want of it by its native sweetness, that art was absent without being missed, and I could not but have some curiosity to see, who was the possessor of so much power to please. Turning then my steps towards that part of the field, whence the voice came, my eyes quickly ceased to envy my ears ; for they discovered, kneeling by a cow, and singing to her whilst she milked her, a person, who, in the habit of a milk-maid, seemed to disguise one of those nymphs, that poets are wont to describe to us. And that you may not wonder, continues *Lindamor*, at what I shall say to you of a country girl, know, that methought I saw in her face something more like *Hermione*, before she proved inconstant, than I expected to find in any of her sex. I will not tell you, that this fair creature had the blushes of the morning in her cheeks, the splendor of the sun in her eyes, the freshness of the fields in her looks, the whiteness of the milk she expressed in her skin, and the melody of the larks we were admiring in her voice, lest you should think Mr. *Boyle's* Seraphick Love had lost its operation on me. But I may perhaps, without much hyperbole, give you this account of her, that though her clothes are almost as coarse as cleanly ; and though they are suited to her condition, yet they are very ill suited to her beauty ; which, as if nature intended a triumph over fortune, has, without any assistance of ornament, more distressed my liberty, than others have been able to do with all their most curious dresses. And this fair creature, continues *Lindamor*, as she is rich in nature's bounty, appeared as well by the cheerfulness of the tune she sung, as by the manner of her singing it, so satisfied with the unpurchased treasures she possesses, that she seemed almost as much pleased as I was to look upon her. This character of *Lindamor's* inviting me to go see, whether or no it were deserved ; and the frequent experience I have had, that even upon such bright eyes as poets, and lovers, called suns, I could gaze undazzled enough to approve my self a right eagle, assuring me I might safely do it, I fearlessly, but softly, approached the place, where the fair milk-maid was solliciting the udder of a fresh cow ; and I found, that though indeed some resemblance she had to *Hermione* had made *Lindamor* flatter her, yet she looked at once so innocently, and prettily, that she seemed like to do mischief, without at all intending it ; and I could not but fancy, that if some ladies, that are much cried up, and are very imperious mistresses, because they are so, were bound to change dresses with this unsophisticated and unadorned maid, the one would appear to owe her beauty to art, and the other to be beholden for her's to nothing but nature. But *Lindamor*, who is not naturally indisposed to be amorous, did not think, that this imagination of mine did that pretty creature right ; for when I told him, she would eclipse a hundred of our fine ladies, if she had but the dress of one of them, Why, that (replies he, with a kind of indignation) she can do without it ; and perhaps, (subjoins he) as much as with it. For her present habit leaves her most her self ; and bravery would but disguise, or hide what it cannot adorn. And I am con-

ident, (continues he) that should such a genuine beauty appear among the gallants, she would really captivate many, even of those wary ones, that do but pretend to be so, to the designing and applauded ladies; for though skill may encounter the wiles of art, it would scarce be able to resist the charms of nature. But whilst *Lindamor* was thus complimenting with what he fancied the picture of his once loved *Hermione*, and had his eyes as much fixed upon her, as dazzled ones could be, the lovely milk-maid, (who all this while having not taken notice of us, was as regardless of *Lindamor*, as he seemed to be of all things but her) having dispatched what she was doing, took up her pail to carry it homewards: but her way chancing to lie by that part of the meadow, where we were yet standing, she could not but discover us; and judging by our clothes, and more by *Lindamor's* mein, that we were of a quality differing from theirs she was wont to converse with, she gave us a salute low enough to let us see, that she forgot not her condition; but attended with so much gracefulness, as made *Lindamor* conclude she merited a better, and, as she passed by him, to return the gesture of respect, which he thought so much beauty had a right in any habit to exact. She vouchsafed him a smile, which, I after told him, would have made him happy, if he had thought it had proceeded from kindness, not civility; and she went away with a look so serene, as well as taking, that she seemed to carry home with her far more quiet, than she left him possessed of. But I, that had lost sight of her, without losing any thing with it, save the expectation of seeing in haste so fair a milk-maid, was going to railly with *Lindamor* about what had passed, when I was restrained, by perceiving, that the sight of a person, that seemed so contented, together with the native pleasantness of that place, and of that glorious morning, had such an operation upon him, that he could not forbear to celebrate the happiness and innocency of a country life. And after he had, with much transport, and fluency, repeated the substance of what *Ovid* and other ancient poets had in their strain delivered, concerning the felicity of the golden age, he began to apply as much of it as the matter would bear, to the recommending of a rural life; and was very solicitous to make me acknowledge, that though we are wont to look upon villagers, as an inferior and wretched sort of people, yet they are the persons of the world, whose condition is the most proper, not only to keep them innocent, but to make them happy; their cheap and simple way of living allowing them to rest contented with what bounteous nature has provided for them, or an easy industry can procure them. Whereas among men nobly born, or persons of quality, it is looked upon as want of breeding, for a man not to think himself unhappy, as long as he hath not a thousand pounds a year.

LINDAMOR, though he here made a pause to take breath, would yet perhaps have prosecuted his discourse, had he not been prevented by the intervening of *Eusebius*, who, a while after we had left him, having missed us, had followed us to the place he found us in, and who, when he drew nigh, having over-heard *Lindamor* speaking, stood still a while at some distance off, to listen to what he said, and so became an unsuspected auditor of the last part of his friend's discourse. Whereupon taking him by the hand, and leading him towards the river, he told him, with a serious, not to call it a severe look; I had thought, *Lindamor*, you had made righter estimates of the several courses of life, than by what I have newly over-heard you to say, I now suspect you do. Know then, *Lindamor*, (adds he) that innocence and contentment depend more upon a man's mind, than upon his condition. To manifest this to you, I shall in the first place observe, that it is not always the occasion, or the object, but rather the degree, that makes an affection of the mind unruly and troublesome: nor is it according to the intrinsic value of things, which none save the wise can discern: but the rate, how unskilfully soever fixt, which we put upon them, that they operate upon

upon our passions. And therefore, you shall see a child take on more sadly for the scape of a sparrow, or the breaking of a rattle, than some will do for the loss of a good estate, nay, of a friend; and *Haman*, for the want of a bow from *Mordecai*, complained more in his palace, than *Job*, till his miserable comforters had exasperated his grief, did for the loss of the biggest fortune in the East, and of the children he reserved it for, and valued far above it.

AND then, *Lindamor*, (continues *Eusebius*) do not imagine, that though courtiers and gallants have more splendid and glittering temptations to sin and discontent, country people are exempted from temptation to either: theirs may be as great, though not the same, nor so specious as the other; their faults and infelicities are indeed less taken notice of, because their persons and conditions are obscure, and their poverty conceals their vices, as well as their virtues, from our eyes; as in a sharp winter, the snow does as well hide their dung-hills, as cover their gardens. But if your quality allowed you to acquaint yourself with the true state of this inferior sort of people, you would soon perceive, that even of rural families, there is scarce any, that, as far as their wits will reach, has not its several parties, and little intrigues; nor is there any cottage so low, and narrow, as not to harbour care, and malice, and covetousness, and envy, if those, that dwell in it, have a mind to entertain them. And what envy alone may do to produce crimes and discontents, we may conjecture by what happened betwixt *Cain* and *Abel*, since their being heirs to the whole world could not keep two brothers at peace, whilst one of them was envious: and there are some sordid vices, which are more incident to the meaner and more necessitous sort of men, as spiders and cobwebs are wont to abound more in thatched cabins, than in great men's houses. I should perhaps (says *Eusebius*) think these people happy, if I found they thought themselves so; but the pomp and vanities of the world have oftentimes stronger allurements for them, than for the grandees and courtiers themselves: for those, that are possessed of these imaginary joys, are disabused by their own experience; and those, that live among these theatrical persons, are near enough to discern, that they are but causelessly envied. As, for my part, when I had occasion to be conversant in great men's families, and the honour to preach in princes courts, the sight of their course of life did as thoroughly convince me of the vanity of the world, as my sermons endeavoured to convince them. Whereas country people see but the glittering and deluding outside of greatness; and beholding it at a distance, see it in the favourablest light which men can behold it in; and consequently are strongly tempted to envy what they admire, and repine at their own condition, for the want of it: nay, every gaudy trifle, that those that live in towns and cities chance to make shew of, is wont to make a country-man envy, as well as gape; and it is odds, but that very milk-maid, whose condition you are pleased to think so happy, envies some neighbouring farmer's daughter for a piece of taudry ribbon, or a black hood. Nor are they so much more privileged from the assaults of temptation, than men of higher rank; for it is not so much a man's outward condition, as his inward disposition and temper of mind, that makes temptations either to sin, or to discontent, prevalent, or unsuccessful. When *Joseph* was sold into *Egypt*, and solicited by a woman, that would needs be his mistress upon more scores than one, though his condition exposed him more to hopes and fears, than almost any other condition could expose another man; and though his youth made him very capable of relishing the pleasures, that his beauty made him courted to receive, by giving them: yet this chaste youth chose rather to be imprisoned any where, than in a fair lady's arms, and preferred the being made a captive, before the captivating of his amorous mistress. But whilst young *Joseph*

was thus chaste in the Egyptian *Potiphar's* house, his eldest brother *Reuben* was incestuous in good *Jacob's*, whose family was then the visible church of God; and *Lot*, who was chaste and temperate in *Sodom* itself, was drunk, and committed incest in a cave: so much more does the success of temptations depend upon the temper of a man's mind, than upon the place he lives in.

I know not (says *Eugenius*) whether the innocence of rural people be more easy than that of great men, but sure it is not so commendable: for as a woman, that has never yielded, because she was never solicited, may be called rather innocent than virtuous; so their condition, that owe their not being inveigled by the vanities of the world to their ignorance of them, has more in it of good fortune than of merit. I thank you for that consideration (subjoins *Eusebius*) for I confess I think there is a great disparity betwixt an unacquaintedness with the bewitching pleasures of the world, and a contempt of them. And he is the truly heroick spirit, that can (as *David* could) plentifully enjoy all those sensual delights and vanities he chose to reject: for he could feast a nation, and prefer temperance before all that abundance: he could gain strange victories at once over his outward enemies, and over the temptations he was exposed to by such successes: he could build stately palaces, and then profess himself to be but *a stranger, and a sojourner upon earth*: he could afford humility room to sit with him on his throne, and could listen to her mementoes amidst all the acclamations of his people, and the panegyrics of his courtiers: he was not to be resisted by beauties, that to others were irresistible, when he postponed the fairest objects, that could here charm his eyes, to such as were visible only to those of faith: he had got together the greatest treasure, that for aught I remember we read of in any history, and yet seems never to have been much pleased with it, but when he dedicated it to the building of the temple, and made the fruits of his valour the oblation of his piety. To be short, he was the greatest person upon earth, when he was content to leave it; and was willing to descend from the throne into the grave, whilst he looked upon that as the place whence he must ascend to the mansion of his God: so much did he, even whilst he wore an earthly crown, aspire to an heavenly one. And though (continues *Eusebius*) we must now-a-days as little expect to meet with a man of *David's* condition, as of his temper, yet proportionably we may put a vast difference betwixt those that but escape the sight of the world's allurements, and those that reject the profers of them.

EUSEBIUS was in this part of his discourse, when we were come near enough to the river, to discover it within a little way of us: and therefore finding by his silence, that he thought it seasonable to desist, I only ventured to tell him with a low voice, as we continued our walk, that I suspected, that in some of the things he had been saying, he had a design rather to check *Lindamor* a little, and keep up the discourse, than to deny, that a retired and rural life has great advantages towards contentation. To which, that he might conclude what he had to say, before we reached the river, he made haste to reply in the same tone, that I was not altogether mistaken; for (says he) I think the case may be pretty well represented, by saying, that as there are some airs very much wholesomer than others, and fitter to preserve men from diseases; so a very private and quiet condition of life does, much more easily than a more exposed and turbulent one, protect most sorts of men from vices and disquiets. But then, on the other side, as there are some men of such sound and strong constitutions, that they will enjoy their health in the worst airs, when men of tender and vitiated complexions will be sickly in the best; so there are some generous and steady souls, that will pass thorough the most troublesome and most exposed courses of life, with
more

more of both innocence and contentment, than others can enjoy in a condition far remoter from disturbances and temptations. And, annexes *Eusebius*, (purposely raising his voice) as for these villagers, that *Lindamor* thought so happy, I must dissent from him, as long as I see they can admire, and almost worship, a man for wearing a gaudy suit of clothes, or having two or three footmen behind his coach, before they know whether he be not a knave, or a fool, or both: for I shall scarce think, that he, who is himself possessed with envy, deserves mine.

DISCOURSE IV.

Upon fishing with a counterfeit fly.

BEING at length come to the river-side, we quickly began to fall to the sport, for which we came thither; and *Eugenius* finding the fish forward enough to bite, thought fit to spare his flies, till he might have more need of them, and therefore tied to his line a hook, furnished with one of those counterfeit flies, which in some neighbouring countries are much used, and which being made of the feathers of wild-fowl, are not subject to be drenched by the water, whereon those birds are wont to swim. This fly being for a pretty while scarce any oftener thrown in, than the hook it hid was drawn up again with a fish fastened to it, *Eugenius* looking on us with a smiling countenance, seemed to be very proud of his success: which *Eusebius* taking notice of, Whilst, (says he) we smile to see, how easily you beguile these silly fishes, that you catch so fast with this false bait, possibly we are not much less unwary ourselves; and the world's treacherous pleasures do little less delude both me and you: for, *Eugenius*, (continues he) as the Apostles were fishers of men in a good sense, so their and our grand adversary is a skilful fisher of men in a bad sense; and too often in his attempts, to cheat fond mortals, meets with a success as great and easy, as you now find your's. And certainly, that tempter, as the Scripture calls him, does sadly delude us, even when we rise at his best baits, and, as it were, his true flies: for, alas! the best things he can give, are very worthless, most of them in their own nature, and all of them in comparison of what they must cost us to enjoy them. But, however, riches, power, and the delights of the senses are real goods in their kind, though they be not of the best kind; yet, alas, many of us are so fitted for deceits, that we do not put this subtle angler, to make use of his true baits to catch us! We suffer him to abuse us much more grossly, and to cheat us with empty titles of honour, or the ensnaring smiles of great ones, or disquieting drudgeries, disguised with the specious names of great employments. And though these, when they must be obtained by sin, or are proposed as the recompences for it, be, as I was going to say, but the devil's counterfeit flies: yet, as if we were fond of being deceived, we greedily swallow the hook, for flies, that do but look like such; so dim-sighted are we, as well to what vice shews, as to what it hides. Let us not then, (concludes *Eusebius*) rise at baits, whereby we may be sure to be either grossly, or at least exceedingly deceived; for, whoever ventures to commit a sin, to taste the luscious sweets, that the fruition of it seems to promise, certainly is so far deceived, as to swallow a true hook for a bait, which either proves but a counterfeit fly, or hides that under its alluring shew, which makes it not need to be a counterfeit one to deceive him.

DISCOURSE V.

Upon a fish's struggling after having swallowed the hook.

FORTUNE soon offered *Eusebius* a fair opportunity to confirm this last part of his reflection; for he had scarce made an end of it, when a large fish, espying the fly, that kept my hook swimming, rose swiftly at it, and having greedily chopt it up, was hastily swimming away with it, when I struck him, and thereby stopt for a while his progress: but finding himself both arrested and wounded, he struggled with so much violence, that at length he broke my slender line, (that was fitted but for weaker fishes) and carried away a part of it, together with the annexed hook and bait. If philosophers (says hereupon *Eusebius*) be not too liberal in allowing brutes to think, we may well suppose, that this fish expected a great deal of pleasure from the bait he fell upon so greedily; and that when once he had got it into his mouth, he might well look upon it as his own; and those other fishes, that saw him swallow it, and swim away with it, did probably envy his good fortune. But yet indeed he does not enjoy his wish, though he seem to have the thing wished for within his power: for by the same action, in which he sucked in the fly, he likewise took in the hook, which does so wound and tear his tender gills, and thereby put him into such restless pain, that no doubt he wishes, that the hook, bait, and all, were out of his torn jaws again, the one putting him to too much torture to let him at all relish the other. Thus men, who do what they should not, to obtain any object of their sensual desires, whatever pleasure they may beforehand fancy to themselves in their success, are oftentimes, even when they obtain their ends, disappointed of their expectations; sometimes conscience, reason, or honour, making them, even when their desires are not of the worst sort, do as *David* did, when he had, more vehemently than became a pious general, longed for water out of the well at *Bethlehem*; and by the strange venturousness of his bold and affectionate officers obtained it, could not find in his heart to drink it, but poured it untasted on the ground. But when the things we so long for must be criminally obtained, then it not only often fares with them, as it did with *Amnon*, who immediately upon the incestuous fruition of his ravished sister, hated her more than before he had loved her: but it sometimes happens to those, that sin more heinously in this matter, as it did to *Judas*, who, after having betrayed a master, that was incomparably more worth than all the world, and thereby for ever lost himself for a few pieces of silver, seemed to have it in his power, without having it in his will, to enjoy them, and in a desperate but unseasonable fit of anguish and remorse, did of his own accord disburthen himself of that money, which he had sold his conscience to get; so that though he had what he sought, he had not what he expected. And when what he coveted was in his possession, he had the guilt of acquiring it, without the power of enjoying it. And even in cases far less heinous, (concludes *Eusebius*) when men seem to have got what they aimed at, and to have carried it away as their booty, in spite of all opposition, the wound thereby inflicted on injured conscience puts them to so much of deserved pain, that the wishes they are thus criminally possess of, they do not enjoy, but detest.

DISCOURSE VI.

Upon the sight of one's shadow cast upon the face of a river.

THE sight of some fishes playing to and fro upon the top of the water diverted us from prosecuting our conference, and drew us to apply our selves attentively to the catching of them, in which accordingly we spent some part of the morning; yet whilst we continued angling, not far from one another, we often cast our eyes (as is usual in such cases) upon each other's fishing corks, to learn as well the success of our friends, as in what places the fish were forwardest to bite. As I chanced to look towards that cork, at which *Eusebius's* hook was hanging, I perceived, that it was divers times drawn under water, without his endeavouring thereupon to strike that fish, that made thus bold with his bait: wherefore laying down my angle a while, I went softly towards *Eusebius*, to see what it was, that made him so regardless of his sport, whilst yet, by the posture he continued in, he seemed to be intent upon it; but approaching near enough, I quickly perceived, that instead of minding his hook, his eyes were fixt sometimes upon his own picture, reflected from the smooth surface of the gliding stream, and sometimes upon the shadow projected by his body, a little beside the picture upon the same river.

THE unwilling noise I made in coming so near having obliged *Eusebius* to take notice of me, I thought fit, since I found I was discovered, to ask him smilingly, whether he were, *Narcissus*-like, making love to his own shadow.

EUSEBIUS guessing by these words, that I had conjectured what he was doing, answered me with a look somewhat more serious than that I had spoken to him with; I was indeed, *Philaretus*, attentively enough considering, sometimes my picture, which the water presents me with, and sometimes the shadow, which the sun and I together cast upon the water: but (says he, with a half smile) I looked upon both these, not with the eyes of a *Narcissus*, (for that would make me much madder than he was) but with those of a Christian. For I was considering, that one of the differences betwixt the law and the gospel, might not be ill represented by the difference betwixt a common looking-glass, and that afforded me by this crystal stream: for though, both being specular bodies, I can see my face in either; yet if my face be spotted with dirt, or grown pale by reason of the faintness usual in such hot weather, a common looking-glass will indeed discover those things to me, but will not otherwise assist me to remedy them; whereas, when I consult this stream, if it shew me any spots in my face, it supplies me with water to wash them off, and by its cooling and refreshing waters, can relieve me from that faintness, that reduces me to look pale.

Thus the law, which is commonly, and which seems even by an Apostle to be compared to a looking-glass, shews us indeed the pollutions of our souls, and discovers to us the effects of our spiritual languidness, and faintness; but the gospel does not only do so, but tells the embracers of it, by Saint *John's* mouth, *If any man sin, we have an advocate with the Father, Jesus Christ the righteous, who is the propitiation for our sins, and whose blood cleanses us from all sin.* And the author of the same gospel invites all those, that find themselves tired and thirsty, to come unto him, and to be refreshed.

By this time *Lindamor*, who was angling not very far off, perceiving us stand together, as if we were engaged in some discourse, laid by his rod a while, and came to listen to what he expected he might learn from *Eusebius*; who pausing here, I put him in mind, that he had also mentioned to me the sight of his

shadow upon the face of the river, as another object of his contemplations, and that therefore my curiosity (wherein I knew *Lindamor*, as soon as I should acquaint him with the occasion, would share) made me very desirous to know what thoughts had been suggested to him by a subject, that seemed so slight and barren.

SINCE you will needs know, (replies *Eusebius*) I will confess to you, that my thoughts were theologically enough employed, and therefore, lest you should think, I affect to preach out of the pulpit, I will but succinctly mention some of those various things, that this shadow, as despicable as you think it, suggested to me: but since I was only entertaining and exciting my self, not discoursing with Naturalists, or disputing with Atheists, I presume you will not wonder, that I take the doctrine of the creation for granted, as it is acknowledged by Christians in general, and particularly by you.

I WAS then considering, that this shadow, related to me, might in some particulars be no unfit one of the universe in reference to God: and indeed, perhaps the world may without much extravagance be termed the shadow of him, of whose attributes, or perfections, it exhibits to an attentive considerer divers excellent impresses, and the resemblance may thus far be advanced: that as though it represents the shape and out-lines of my body, which projects it, yet it represents but them, and consequently this shadow in reference to it is but a superficial and worthless thing; so the world, though it be not destitute of several impresses, and as it were lineaments or features of the divine wisdom and power, yet, for all this, its representations of the divine Author of it are but very imperfect, superficial, and dark, and the excellency of the adorable author of things keeps him infinitely above all the works, that he has made.

Pf. xxxiii.
9.
Isaiah xl.
28.

BUT to mention some of the comparisons I took notice of: In the first place we may consider, that I make this shadow here without taking the least pains to do so, and with as little toil God made the world: *He spake and it was done; he commanded and it stood fast*, (says the Psalmist, speaking of the creation.) And elsewhere the scripture says, *That the everlasting God, the Lord, the Creator of the ends of the earth fainteth not, neither is weary*; and therefore that rest ascribed him on the seventh day is to be understood but a cessation from creating, not a repose from labour: for all disproportions to the power of created agents are so equally inconsiderable, in reference to one that is infinite, that omnipotence may make even the world without toil.

Revel. x.
6.
Hebr. xi.
3.

SECONDLY, To make this shadow, I neither use nor need colours, nor pencil; I dig no quarries, nor fell no trees to perfect this work, and employ no materials about it: as little had God any pre-existent matter to contrive into this vast fabrick: our creed proclaims him the Creator of heaven and earth; the angel, that holds the book, in the *Revelations*, describes him resemblingly; and the Apostle tells us, *That through faith we understand, that the worlds were framed by the word of God; so that things, which are seen, were not made of things, that do appear*. And indeed it became an omnipotent architect, not to be beholden but to himself for his materials. He that calleth things, that are not, as though they were, makes them by calling them; *He brought forth light out of darkness, by calling for light, and there was light; and he spake it, and it was done*, says the Psalmist: and the world was, if I may so express it, but the real echo of that productive *FIAT*.

THE next thing, I was considering, was, that, to destroy this shadow, I needed neither sword, nor pistol, the withdrawing of my self under the neighbouring trees.

being

being sufficient to make the shadow disappear, and leave behind as little shape of it, as if there never had been any. And thus, as the world could not have had a beginning, without having been provided by God, so for the continuance of the being it enjoys, it depends altogether, and every moment, upon the will and pleasure of its first author, of whom St. Paul tells us, *That in him we not only live, and move, but have our being*; and to the same purpose I think one may alledge that place, where the scripture says of God, not only, *that he has made heaven, the heaven of heavens with all their host, the earth and all things that are thereon, the seas and all that is therein*; but adds, *that he preserveth them all*, as our translators English it: for in the Hebrew I remember it is, *vivifies them all*, that is, sustains them in that improper kind of life, or that existence, which, whilst their nature lasts, belongs unto it. So that if God should at any time withdraw his preserving influence, the world would presently relapse, or vanish into its first nothing, as there are many notions of the mind such, as that of genus, and species, which are so the creatures of reason, that they have no longer an existence in the nature of things, than they are actually upheld therein, by being actually thought upon by some intellectual being; and God is so the preserver of all his creatures, that one may say of the rest, as the Psalmist speaks of many of them, where addressing himself to God, he says; *Thou hidest thy face, they are troubled: thou takest away their breath, they die, and return to their dust; thou sendest forth thy spirit, they are created, &c.*

Nehemiah
ix. 6.

Psal. civ.
29, 30.

I was also taking notice, (pursues *Eusebius*) that to produce what changes I pleased, in all, or any part of this shadow, I needed not employ either emissaries, or instruments, nor so much as rouse up my self to any difficult exertion of my own strength, since by only moving this or that part of my own body, I could change at pleasure, in the twinkling of an eye, the figure and posture of what part of the shadow I thought fit: and thus, when God had a mind to work those miracles, we most admire, as when at *Joshua's* prayer he stopped the course of the sun, and at *Hezekiah's*, made him go back; we men are apt to imagine, that these prodigious effects must needs cost their author much, and that he must strain his power, and be necessitated to a troublesome exertion of his omnipotence, to be able to produce them: whereas to that divine agent, those things, that would be to all others impossible, are so far from being difficult, and the creatures have so absolute and continual a dependance on him, that it is as easy for him to effect the greatest alterations in them, as to resolve to do so. And even those miraculous changes of the course of nature, that do the most astonish us, do so naturally and necessarily flow from the motions of his own will, that to decree, and to execute, (whether or no they require powers otherwise than notionally differing) are alike easy to him: and that irresistible agent finds as little more difficulty to produce the greatest changes among the creatures, than to produce the least, as I find it harder to move the whole arm of my shadow, than to move its little finger. And this consideration (subjoins *Eusebius*) might be, methought, consolatory enough to his church, who, by reposing an entire trust in her God, entitles her self to the protection of him, that can as easily produce changes in the world, as resolve on them, and can with the same facility destroy her and his greatest enemies, as decree their destruction.

I was also further considering, (says *Eusebius*) that though the little watry bodies, that make up this river, and consequently those, that glided along by me, were in a restless motion, the hindmost always urging on, and chasing those that were before them; yet my shadow was as compleat and stable upon the fugitive stream, as if it had been projected on the water of a pond, or rather as if all the parts of water, whereon it was visible, had been fixt and moveless; of which I made this application,

that though we may say with *Solomon*, in a larger sense than his, *That one generation goes, and another comes*, the world being maintained by perpetual vicissitudes of generation and corruption, yet the wisdom and providence of God does so far confine the creatures to the established laws of nature, that though vast multitudes of individuals are always giving place to others, yet the particular creatures, which do at any time make up the world, do always exhibit the like picture of its divine original.

BUT yet lastly, (says *Eusebius*) I was considering too, that though this shadow have some kind of resemblance to that, whose shadow it is, yet the picture is but very superficial and obscure; and if we should suppose, the fishes, that inhabit this stream, to be endued with reason, they could even from *Lindamor's* shadow but collect, that the original is a man, and not a brute; but they could not hence make any discovery of what manner of man he is, nor know any thing of his virtues, or his thoughts, or his intention, nor consequently have that notion of him, that I (pursues *Eusebius*, turning to him, and a little smiling on him) do harbour and cherish, who having the happiness to converse with him, have the opportunity and the justice to admire him. Thus, where I formerly ventured to call the world God's shadow, I did not forget, how imperfect a picture a shadow is wont to be: and though this dark representation, that God has vouchsafed men of himself in the universe, be sufficient to convince us, that it was not made by chance, but produced by a powerful and intelligent being; the eternal power and God-head of the great author of nature, as the scripture seems to teach us, being manifested to attentive and rational considerers, in the visible productions of his power and wisdom; yet how short and dim a knowledge must they have of him, that have no other than these corporal instructors? How many of his glorious attributes are there, for whose knowledge we must be beholden, rather to his written, than his created word? and how little will human intellects, without revelation, discover of that manifold wisdom of God, which the scripture teaches us, *That even to the angels it must be made known by the church*. And if those illuminated persons, such as *Moses* and *St. Paul* himself, who had both extraordinary revelations from God, and intimate communion with him, confessed, that in this life they saw him but darkly, and, as it were, in a glass; sure the dim light of mere nature will give us but extremely imperfect, and detracting ideas of him, whom the like limitedness of our nature will allow us to know but very imperfectly, in heaven it self; though, as we shall there see him face to face, our apprehensive faculties will as well be enlarged, as the dazzling and ravishing object be disclosed.

Ephes. iii.
10.

BUT, (says *Eusebius*) though I forget, that I am not in the pulpit, I hope you remember, that I told you at first, how little I pretended these kind of reflections would endure a rigorous philosophical examen; and that I am not so indiscreet, as to expect, that they should work conviction in an infidel, though I hope they may excite good thoughts in a believer.

THESE last words of our friend being not followed by any other; *Lindamor*, having waited a while to ascertain himself, that *Eusebius* had ended his discourse, began another, by saying:

I PERCEIVE, *Eusebius*, with much more satisfaction than surprize, that the same subject, and at the same time, did, as it was fit, suggest very differing considerations to you and me; for whilst your shadow afforded you the rise of sublime speculations, I was making but a moral reflection upon mine: for taking notice, (continues he) that the shade my body projected, near noon, was almost as much shorter than it, as in the morning it was longer, prompted me to think, how foolish it were for me, who know by sure ways of measuring my own stature, that it is moderate enough,

not

not to be either proud of, or complained of, should imagine, that I am either as tall as a giant, or as low as a dwarf, because I see my shadow either exceeding long, or extremely short. And I was further considering, pursues *Lindamor*, that if philosophers, as well as the vulgar, have rightly called fame or glory the shadow of virtue, it would be as irrational to estimate one's self not by the testimonies of one's conscience, which is the authentick standard of intrinsic worth, but by the fickle opinions of others, (which oftentimes flatter, and oftener detract) but very seldom give a just and impartial estimate of merit: the fame may have its increase and decrements, whilst the person continues the same, and loses nothing of substance with the shadow. And for a man, that should examine himself, and judge of himself by his own designs, and actions, not other men's words, to suffer himself to be puffed up by vulgar applause, or dejected by unmerited censures, were to mistake a shadow for a standard.

DISCOURSE VII.

Upon a fall occasioned by coming too near the river's brink.

IT was not long after this, that *Eugenius* chancing to spy a little nook, which seemed to promise him a more convenient station for his angling, he invited *Lindamor* to share the advantage with him, and began to walk thitherward along the river's brink, which the abundant moisture of the waters, that glided by it, had adorned with a pleasant verdure; but he had not marched very far, when chancing to tread on a place, where the course of the water had worn off the bank, and made it hollow underneath, he found the earth falter under him, and could not hinder his feet from slipping down with the turf that betrayed him; nor could he have escaped so, had not his endeavours to cast the weight of his body towards the bank been assisted by *Lindamor*, who, though not so near the brink as to be in danger, was not so far off, but that he was able to catch hold of him, and to draw him to the firm land. The noise, that *Lindamor* made, when he saw his friend falling, quickly drew *Eusebius* and me thither; where, after I had a while made my self merry with the disaster, I found to have been so harmless; *Eusebius* (who arrived there a little later) asked him how he came to fall; and *Eugenius* answering, that he thought he had trod upon firm ground, because he saw the bank look to the very edge, as if it differed not from the rest of the field, which it terminated: *Eusebius* took occasion from thence to tell him, You may from this take notice, that it is not safe travelling upon the confines of what is lawful, and what is sinful; no more than upon the borders of two hostile nations: when we suppose, that thus far we may go, towards that which is sinful, without committing it, we are wont with more boldness than considerateness to conclude, that we need not scruple to venture, or rather that we shall run no venture, having firm footing all the way. But it is much to be feared, that when we allow our selves to come as far as the utmost verge of what is lawful, and to do that, which, in the casuist's language, is *tantum non* to sin, the natural proclivity of our minds to evil, which carries them downwards, as weight does our bodies, will some time or other make us find hollow ground, where we presume to find it firm. He that to-day will go towards sin as far as he thinks he may, is in danger of going to-morrow further than he should; and it is far more easy for him to be secure than to be safe, that walks upon the brink of a precipice. He was a wise man, that as soon as he had forbidden his son to enter into the path of the wicked, and to go in the way of evil men, subjoins, as the best course to conform to the prescription, Avoid it, pass not by it, turn from it, and pass away. God's indulgence leaves us a latitude

latitude to comply with our infirmities, and necessities, and to give us opportunities of exercising a pious jealousy over our selves, and of shewing how much we fear to offend him. But a wary Christian will say in this case, as *St. Paul* did in almost a like, *all things are lawful for me, but all things are not expedient*: and he must often go further than he can with prudence, that will always go as far as he thinks he can with innocence.

DISCOURSE VIII.

Upon the good and mischief that rivers do.

THIS discourse being ended, we all, as it were, by common consent, applied ourselves again to prosecute the sport that had invited us to the river: but we had not angled very long, before we were disturbed by a confused noise, which we soon discovered to proceed from a ship, that, together with some barges, and other lesser boats, were, by the help of a favourable breath of wind, sailing up the river towards *London*. The sight of these laden vessels, together with the prospect of the *Thames*, which, (as it happened in that place) seemed, in various windings and meanders, wantonly to fly, and to pursue it self: this sight, I say, together with the rich and flourishing verdure, which the waters, in their passage, bestowed upon all the lands, that were on either side any thing near their banks, invited *Eugenius* to fall upon the praises of that excellent river, which not only imparts fertility and plenty here at home, by enriching all the places that have the advantage to be near it; but helps to bring us home, whatever the remoter parts of the world, and the Indies themselves, whether east or west, have of rare or useful.

LINDAMOR, having both applauded and recruited these commendations, Methinks, says he, that amongst other good things, wherewith this river furnish us, it may supply us with a good argument against those modern Stoicks, who are wont, with more eloquence than reason, to declaim against the passions, and would fain persuade others, (for I doubt whether they be so persuaded themselves) that the mind ought to deal with its affections, as *Pharoah* would have dealt with the Jews-males, whom he thought it wise to destroy lest they might, one day, grow up into a condition to revolt from him. But because the passions are (sometimes) mutinous, to wish an apathy is as unkind to us, as it would be to our country, to wish we had no rivers, because (sometimes) they do mischief, when great or sudden rain swells them above their banks.

WHEN I consider, (says *Eusebius*) that of the immaculate and divine lamb himself, it is recorded in the gospel, that *he looked round about, upon certain Jews, with indignation, being grieved for the hardness of their hearts*; so that two passions are ascribed to Christ himself in one verse: and when I consider too the indifferency (and consequently the innocence) of passions in their own nature, and the use, that wise and virtuous persons may make of them, I cannot think we ought to throw away (or so much as wish away) those instruments of piety, which God and nature has put into our hands; but am very well content we should retain them, upon such conditions, as *Abraham* did those domesticks he bought with his money, whom, the Scripture tells us, *he both circumcised and kept as servants*.

BUT, (continues *Eusebius*) as I do not altogether disallow *Lindamor's* comparison between rivers and passions, so he must give me leave to add this to it, that as rivers, when they over-flow, drown those grounds, and ruin those husbandmen, which whilst they flowed calmly betwixt their banks, they fertilized and enriched; so our passions

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(when they grow exorbitant and unruly) destroy those virtues, to which they may be very serviceable whilst they keep within their bounds.

INSTANCES of this truth, (pursues *Eusebius*) are but too obvious. It is said, that valour is anger's whetstone; and our being counselled by the apostle, *to be angry and not to sin*, argues that passion not to be incompatible with innocence, whilst it is confined within the limits of moderation. But when once anger is boiled up into rage, or choler into an habitual fury, or appetite of revenge, it makes more havock in the world than beasts and inundation: the greatest part of those rivers of blood, that are shed in battles, (though spilt by anger) do rather irritate than appease the unnatural thirst of that insatiate fury: the burning of cities, the sinking of fleets, and the desolations of provinces, and of kingdoms, make but part of the tragick effects of this inhuman passion, when it once thoroughly possesses those, that wield scepters, and handle swords.

I WILL not tell *Lindamor*, that even that noblest and best of passions, love, as gentle and amiable as it appears, when once it comes to degenerate by growing unruly, or being misplaced, is guilty of far more tragedies than those, that have the fortune to be acted on theatres, or to furnish the writers of romances; and that which (perchance at first) seems to be but an innocent love, being not duly watched, and regulated, may, in time, grow to disobey, or deceive parents, to violate friendships, to send challenges, and fight duels, to betray the honour of harmless virgins, and of the noblest families, to rebel against kings, procure the ruin of monarchies and commonwealths; and, in a word, to make thousands miserable, and those it possesses most of all, and thereby to bring credit to, if not also to surpass, the fictions of poets, and the fabulous stories of romances:

AND as for the desire of excelling others, as great and noble things as it makes men undertake, whilst it aspires only to a transcendency in virtue, and in goodness, when that passionate desire, by making men too greedy of superiority in fame and power, degenerates into ambition; how many vices are usually set at work by this one passion! The contempt of the laws, the violation of oaths, the renouncing of allegiance, the breach of leagues and compacts, the murder of one's nearest relations, (if they be more nearly related to a crown) and all the other crimes and miseries, that are wont to beget or attend civil wars, are the usual as well as dismal productions of this aspiring humour in a subject. Nor does it less mischief when harboured in a prince's breast; for the undoing of his own people, the subversion of his neighbour's states, the sacking of cities, the slaughter of armies, the dispeopling of some provinces, and the peopling of others with widows and orphans, are sacrifices, that are more frequently offered up to ambition, than able to satisfy it. For what can quench his thirst of rule and fame, or hinder the attempts, to which it stimulates him, that can find in his heart to destroy armies, and ruin provinces, only that he may be taken notice of to be able to do so?

CERTAINLY (subjoins *Eusebius*) he knew very well the frame of human spirits, that said by the pen of an Apostle; *From whence comes wars and brawlings among you? Come they not hence, even of your lusts that war in your members.* And I doubt not, whether plagues, wars, and famines have done more mischief to mankind, than anger and ambition, and some other inordinate passions; for these do frequently bring upon men those publick and other fatal calamities, either as judgments, which they provoke God to inflict, or as evils, which as proper consequents naturally flow from those mischievous practices, to which unbridled passions hurry the criminally unhappy persons they have enslaved.

WHEREFORE,

WHEREFORE, (concludes *Eusebius*, casting his eyes upon *Lindamor*) as the usefulness of a river hinders us not from making good the banks, and, if need be, making dams, to confine it within its limits, and prevent its inundations; so the usefulness of the passions should not hinder us from watchfully employing the methods and expedients afforded us by reason and religion, to keep them within their due bounds, which they seldom overflow without shewing, to our cost; that, as it is observed of fire and water, they cannot be so good servants, but that they are worse masters.

DISCOURSE IX.

Upon the comparing of lands, seated at different distances from the river.

THIS last discourse, to which the river had afforded the occasion, inviting me to survey as much of it, as was within my view, a little more attentively, gave me the opportunity of taking notice of a manifest difference betwixt the lands that lay near it, and those whose situation was remoter from it; and having acquainted *Eusebius* with what I had observed, which his own eyes could not but presently bear witness to; One (says he) that should only consider how swiftly this stream runs along these flowery meadows, and how great a quantity of water passes through them, and from them, towards the sea, would be apt to conclude, that certainly these grounds retain none of the water, which runs from them so hastily, and so plentifully; especially since we can see no channels, nor other manifest inlets, and receptacles, that should divert and retain the fugitive water, so that the grounds confining on the river must be but little advantaged by its neighbourhood. But, (continues *Eusebius*) though these grounds have not any patent passages, whereby to derive water and fatness from the river, and therefore must suffer the greatest part of it to run by them undiverted; yet still some of the cherishing and fertilizing moisture is from time to time soaked in by the neighbouring ground, and (perhaps by blind pores and crooked channels) so dispersed thorough the whole fields, that they have thereby water, and in that vehicle fertility conveyed to them; which you will not doubt, if you do but with me take notice, how much the lands, that lie on both sides near the course of the river, are more verdant, and flourishing, and more rich, than those less happy grounds, to whom their remoteness denies the advantages of so improving a neighbourhood.

THUS (resumes *Eusebius*) many a pious person, that is an assiduous attendant on the means of grace, and has a care to place himself, as it were, in the way, by which the ordinances of God, especially those of reading and expounding of the Scriptures, are wont freely and copiously to flow, is (especially upon any fit of melancholy, or distress of mind) apt to be extremely discouraged from prosecuting that course of duties; and by looking upon the little, that he remembers of so many excellent sermons as he has heard, he is often inclined to conclude, not only he has lost all the good sermons, that he has heard already, but that at least for such as he, there is little to be expected from them for the future.

BUT though to lose so much of a thing, so precious as the doctrine of salvation, be that, which is oftentimes a fault, and always an unhappiness; yet it is a far less mischief to forget sermons than to forsake them; the one may be but an effect of weak memory, the other is that of a depraved will, perverted by laziness, impatience, or some greater fault. We should scarce allow it for a rational proceeding, if one in a consumption, or dysentery, because he grows not fat with feeding, should resolve to renounce eating and drinking.

BUT this (says *Eusebius*) is not that, which I chiefly intended: for pious, but melancholy persons, are oftentimes too partial against themselves, to be competent judges

judges of their own estate; they seem not to forget any sermon so much, as that charity should begin at home; and they are much more careful not to accuse any body wrongfully than themselves: though they might remember, that in the estimate of Christ himself, all grounds are not equally fruitful, that are good; some bringing forth hundred, some sixty, some but thirty fold, and yet to all he vouchsafes the title of good. And though, as mad men, that have quite lost their wits, seldom or never complain of the want of them; so those, that have forfeited, or are devoid of grace, rarely bemoan themselves of the weakness of it. And it is no mean sign of proficiency in piety, to be apt to deplore one's unproficiency in piety. It is true, that preaching is not always, and I fear not so much as often, the favour of *life unto life*; the perverseness of the hearers making it but too frequently the favour of *death unto death*. But yet, speaking in the general, though it aggravate the sins committed in spite of it, yet it usually hinders many others from being committed; and he, that twice a week is told of God, and duty, and heaven, and hell, has his conscience more awaked, than he, that never hears of any of these things. And if you but compare one of these despondent Christians, we are considering, with the careless sensualists, that fly a rousing sermon, as they should do what it would deter them from; you will easily discern a sufficient disparity between them, to invite you to conclude, that the instructiveness of preaching may, like the moisture of the river, be conveyed but by little and little at a time, and by unperceived passages, and yet be able to impart fertility. For though much run by, yet commonly something will stick; which we may safely conclude, if though we can discern it no other way, it disclose it self by the effects. For it is not always to those, that remember the most of them, that sermons do the most good, as water retained in ponds makes not the bottom flourishing, but the banks; and the efficacy of a sermon is better to be collected from the impression it has on the understanding and affections, than from that it leaves on the memory: whether we retain the particulars faithfully or no, and carry them home with us; yet if a sermon leave us devouter than it found us, if we go from God's ordinances, with a love to them, and a relish of them, and a purpose to frequent them, we may be despondents, but are not altogether non-proficients: that incorruptible seed, by which we are regenerated, being once thrown into an honest heart, may, as our Saviour intimates, grow up we know not well how, and though perhaps by insensible degrees, yet at length attain maturity. To dispatch, (concludes *Eusebius*) whether or no a man can orderly repeat all the particulars that composed the sermon, it does him good, if it either makes him good, or keeps him so; and its operation is to be estimated, not so much by what we remember, as by what we resolve.

WHAT you have been saying, (subjoins *Lindamor*, when he perceived that *Eusebius* had done speaking) suggests to me a reflection, that till now I did not dream of; and though it differ from that, wherewith you have been pleased to entertain us, yet because it is applicable to the same purpose, and occasioned by the same river, I shall without scruple, though, after your discourse, not without blushes, tell you, that it is this; I, among many others, that live near it, have often resorted in hot weather to this river, to bathe my self in it; and after what I have been hearing, I now begin to consider, that though incomparably the greater part of the river run by me, without doing me any good, and though when I went out of it, I carried away little or none of it with me; yet whilst I stayed in it, that very stream, whose waters run so fast away from me, washed and carried off whatever foulness it might find sticking to my skin; and besides, not only cooled me, and refreshed me, by allaying the intemperate heat, that discomposed me, and made me faint, but also helped me to a good stomach for some while after.

Thus (resumes *Lindamor*) I have sometimes found, that a moving sermon, though it did not find me qualified to derive from it the advantages it questionless afforded better auditors; and when I went from it, I found I had retained so little of it, that it seemed to have almost totally slipped out of my memory, yet the more instructive and pathetick passages of it had that operation upon me, as to cleanse the mind from some of the impurities, it had contracted by conversing to and fro in a defiling world, without suffering pollutions to stay long, and settle, where they began to be harboured: and besides, I found that a course of such sermons, as I have been mentioning, did oftentimes (and if it had not been my own fault, would have always done so) both allay those inordinate heats, that tempting objects are but too apt to excite; refresh my drooping spirits, that continually needed to be revived, and raise in me an appetite to the means of grace, which are piety's (and consequently the soul's) true and improving aliments. So that, (concludes *Lindamor*) though I seldom let sermons do me all the good they may, and should, yet I dare not forsake them, because I forget them; since it is to do a man some good, to make him less bad than he was, and to give a value and inclination for the means of growing better than he is.

DISCOURSE X.

Upon a fish's running away with the bait.

THIS reflection of *Lindamor's* was soon followed by another of the same gentleman's, who seeing many fishes rise one after another, and bite at *Eugenius's* bait, which he let them sometimes run away with, that he might be the surer to be able to draw them up, as he afterwards did several of them; See, (says *Lindamor*, as one of the fishes had just swallowed the hook) how yonder silly fish, having at length seized the beloved bait he has been courting, posts away with it as his obtained wish, little dreaming of being himself taken. Thus (continues the same speaker) when greedy mortals have an opportunity to obtain forbidden things, they joyfully run away with them as the goods they aimed at, and when they fondly think they have caught, they are so; and whilst they imagine themselves to carry away a booty, they become a prey: for that he is, in his judgment that never errs, who, whatever he gets into the bargain, loses himself.

THE Scripture (subjoins *Eusebius*) mentions, among other properties of vice, that which it calls the deceitfulness of sin. And the wise man tells us, that wine is a mocker; and it may be one of the reasons of these expressions, that when we think our selves possessed of a sinful pleasure, we are indeed possessed by it, as demoniacks are possessed by the devil, who serves many other sinners, though less perceivedly, as he serves witches, whom he gets the power to command, by seeming to obey them, and to comply with their criminal desires: and, if we compare this with what I was just now observing to you, on the occasion of the counterfeit fly, we may add, that even when sin seems the kindest and most obsequious to us, and to answer, if not exceed our desires, our case may be but like the Canaanitish general's, who, though he had milk brought him by *Jaël* instead of the water he only requested, was but thereby invited to *sleep the sleep of death*, and to have his fears more surpassed than his desires had been.

BUT (pursues *Eusebius*) this may supply us with another reflection; for though this fish seems to have devoured the hook and bait it swallowed, yet in effect it is taken thereby: so the devil, when he had played the serpent and the lion, when he had brought the Jews and Gentiles to conspire against their common Saviour, and had made *Herod* and *Pilate* friends, to make them joint enemies to Christ, and when by these

these means he seemed to have obtained his end, by employing their hands to kill the formidablest of all his enemies; this pursued prey destroyed the seeming conqueror; and death appearing to swallow the Lord of life was, if I may so speak, choaked by the attempt, since he not only was quickly able to say in the Apostle's triumphant language, *O death, where is thy sting? O grave, where is thy victory? but did by death conquer him that had the power of death, that is, the devil*: nay, and made all his followers so much sharers in the advantages of his conquest, as by the same way (which we are informed by the same text) to deliver those, whom the restless fear of death perpetually kept from relishing the joys of life.

2 Cor. xv.
15.
Heb. ii, 14,
15.

DISCOURSE XI.

Upon a danger springing from an unseasonable contest with the steersman.

THIS discourse being ended, *Eugenius*, who was looked upon by us all as the most experienced as well as concerned angler among us, desiring at a good distance a place, which he judged more convenient for our sport, than that we there were in, where the fish began to bite but slowly; he invited the company to this new station: but when we were come thither, finding in a short time, that either it was ill stocked with fish, or that the season of their biting in the places thereabouts was over, he thought it concerned him to provide us some better place. And accordingly, whilst we were yet, by the pleasure of mutual conversation, endeavouring to keep the fishes fullness from proving an exercise to our patience, he walked along the river, till he lighted upon a youth, that by his habit seemed to belong to some boat or other vessel; and having inquired of him, whether he could not be our guide to some place where the fish would bite quick, he replied, that he easily could, if we would take the trouble of coming to a place on the other side of the river, which his master, who was a fisher-man, had baited over night, and would questionless let us make use of for a small gratification. *Eugenius*, being very well content, called away the company, which were led by the youth to a boat belonging to his master; into which being entered, the old man, who was owner of the boat, hoisted up sails, and began to steer the boat with one of his oars, to a place he shewed us at a good distance off; but did it so unskilfully, that since a mariner of his age could scarce mistake so grossly for want of experience in the river, we began to suspect, that he had too plentifully tasted a far stronger liquor than that which was the scene of his trade: and as the old man was half drunk, so the youth appeared to be a mere novice, both which we had quickly occasion to take notice of. For some clouds that were gathering out of the sea, passing over our vessel, raised in their passage, as is usual enough, a temporary wind, that to such a slight boat as ours was might almost pass for a kind of storm: for then the old man gave his directions so ill, and the youth was so little able to execute them punctually, that two of the company, offended at their unskilfulness, began by angry and unseasonable expostulations and clamours to confound the already disordered boat-man; and being got up, with no small hazard to the boat, they would perchance, by crossing the watermen in their endeavours, have made it miscarry, had not *Lindamor*, whose travels had made him well acquainted with such cases, earnestly requested them to sit still, and let the watermen do their own work as well as they could; affirming, that he had seen more than one of those easily over-set boats cast away, by the confused and disagreeing endeavours of the watermen and passengers to preserve it. This counsel was thought very reasonable, since the greater the wind was, and the less the steersman's dexterity, the more necessary it appeared, that we should be orderly and quiet, and by leaning our bodies sometimes one way,

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and sometimes another, as occasion required, do what in us lay to keep the vessel upright: and herein we were so prosperous, that soon after the cloud was passed, and the shower it brought with it was over, the wind grew moderate enough to allow us to make some calm reflections on what had happened. This *Lindamor*, from the thanks that were given him for his advice, took occasion to do in these terms: Since statesmen and philosophers are wont to compare a commonwealth to a ship, I hope the reflection suggested to us by what had just now happened, will be the easier pardoned. The skill of ruling nations is an art no less difficult than noble: for whereas statuarys, masons, carpenters, and other artificers work upon inanimate materials, a ruler must manage free agents, who may have each of them interests or designs of their own, distinct from those of the prince, and many times repugnant to them: and the prizes, that are contended for in government, either are, or (which is in our case all one) are thought, so valuable, and the concurrents are so concerned, and consequently so industrious to drive on each his own design, that without mentioning any of those many other things, which make good government difficult, these alone may suffice to make it more our trouble than our wonder, that the rulers of states and commonwealths should oftentimes mis-govern them. But the publick infelicities of declining states are not always wholly due to the imprudence of the ruler, but oftentimes those, that most resent such imprudency, even by those very resentments increase the publick disorders they appear so much troubled at; and it may be a question, whether it be more prejudicial to commonwealths, to have rulers, that are mean statesmen, than to have a multitude of subjects, that think themselves to be wise ones, and are forward to censure what is done by their magistrates, either because it is done by their superiours, or because it is not done by themselves.

YET it may well be doubted, (says *Eugenius*) whether the reverence and submission we owe to senates or princes extend to our very reasons, and our inward thoughts: for the right, and the skill to govern, are two very distinct things: nor does the one confer the other. A crown, how precious soever, adorns but the outside of the head, without enriching the inside; and its splendour will scarce dazzle a wise beholder's eyes, though it but too often does theirs that wear it. No, the tribunal of reason has a jurisdiction, that reaches to thrones themselves; and what you well observed just now, concerning the difficulty of avoiding faults in government, will, I presume, make you think it excusable, if I confess, that I think sovereigns do now and then do, what you confess it is so hard for them to avoid doing; nor is it more a breach of loyalty, not to think a weak governour a prudent one, than not to think him tall, or straight, or sharp-sighted, if nature have made him low, or crooked, or purblind. A senate or a monarch may indeed command my life and fortune: but as for my opinions, whether of persons, or things, I cannot in most cases command them myself, but must suffer them to be such, as the nature of the things I judge of requires; and therefore, the thinking all things done with wisdom, that are done by men in power, is too great an impossibility to be a duty; and besides, it would lessen the merit of obedience, which otherwise would not appear to be paid to the authority of the magistrate, since we readily obey the injunctions of lawyers and physicians, as long as we think them prudently framed for our good, though we acknowledge not these persons to have any right to command us.

BUT though (continues *Eugenius*) I take reason to be so supreme a thing, that as even the greatest prince's actions should be regulated by it, so they may be judged by it; yet I allow lawful authority a jurisdiction over my actions, that I deny it over my opinions: and though I can obey the orders, that have the impresses of wisdom,

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as well as the stamp of authority, with more hope and alacrity, yet I can obey those, wherein I think power is unguided by prudence, with no less punctualness and fidelity. I would not resist a magistrate, when I cannot esteem him: and though I dare discern folly even in the greatest princes, yet I can reverence authority in the weakest.

I KNOW *Eugenius* too well (says *Lindamor*) not to believe him. But though I confess, that to do what you say, is to do much, and to do that, which I fear is not usually done; yet methinks it were well if we did somewhat more. For whereas most human actions, especially about matters political, are attended with great variety of circumstances, according to some or other of which, they may be differently considered, and estimated; as it is not very difficult to make many, if not most actions appear politick or unwise, according as they are cloathed with those of their circumstances, that may be applied to excuse them, or with those, that are fit to discommend them; so I would take a care to put the favourablest constructions on those publick counsels, that are capable of more constructions than one, and use the parents of my country, as *Noah's* two dutiful children did their distempered father, whose nakedness when they had once discovered, they covered too; and that in such a way, as shewed they were unwilling to see more of it, than was necessary to enable them to hide it. And I say this, (continues *Lindamor*) with relation to *Eugenius*, and such as he; for as to the vulgar, who yet make up the far greatest and loudest part of those, that would intrude themselves into state-affairs, upon the pretence of their being ill managed by their superiours: I cannot but think, that whatever the course of affairs be, these cannot but be incompetent judges of their being politick, or the contrary. For to judge of things barely by success, were somewhat to forget, that there is a supreme and absolute disposer of events, and has been a practice always rejected by the wise, as both discouraging wisdom, and affronting it. And as for the counsels, by which indeed the prudence or imprudence of publick actions is to be estimated, the vulgar is rarely admitted to have such a prospect into the true state of affairs, as is requisite to enable them to judge of the expedience or unadvisedness of them, being unacquainted with the frame and motives of the prince's counsels and designs. Ordinary men may often think that imprudent, whilst they consider it only in it self, which its congruity to the rest of the prince's designs may make politick enough; and a private whisper, or the intimation from an unsuspected spy, or an intercepted letter, or divers other things unperceived, and perhaps undreamt of, by those, that are not of the state-cabal, may make it wise to do several things, which to those, that look only at the actions, without knowing the motives, may appear unpolitick, and would indeed be so, were it not for these reasons, which yet ought to be as little divulged as disobeyed. So that the people's forwardness to quarrel with the transactions of their prince, is usually compounded of pride and ignorance, and is most incident to those, that do not sufficiently understand either state-affairs or themselves: and whilst they judge upon incompetent information, even when their superiours are in the fault, they may be so, for censuring them.

I MUST not now dispute, (says *Eusebius*) whether such as you, gentlemen, whom their conditions, parts and opportunities qualify to discern the interests and designs of princes, may not be allowed to judge of their counsels, and see their errors; as our late astronomers, being assisted with good glasses, are allowed to tell us, that they discern spots even in the sun it self. But, certainly, the ambition of pragmatical inferiours to make themselves statesmen, upon pretence, that those, who sit at the helm, do not govern it as wisely as these would do, if they were in the same places, is a fault no less prejudicial to any state, than epidemical in some of them. For
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whilst the government is thus decried, the same disadvantageous representations embolden strangers and foreigners to attempt the subversion of a state, and make the despondent subjects despair of preserving it; little considering, that there are scarce ever any imprudences in a government, that can prove any thing near so prejudicial to the generality of the subjects, as would the subversion of it, whether by foreign conquest, or by intestine jars; such changes seldom doing less than entail upon unhappy countries the fears and mischiefs of war. And that though it be granted, that the right of governing does not confer the skill, yet it is much better to stick to the former, than oppose or desert it, because it wants the latter: for a right to a crown, is that, which for the most part manifestly belongs but to one, and is seldom plausibly pretended to by above two or three; whereas the skill to govern is so undetermined, and so uncertain a thing, that men's innate pride and self-love would incline almost every man to claim it for himself, especially, since by challenging that, he might put in for no less than sovereignty. And in a state thus abandoned to the craftiest or the strongest, there would never want disturbing vicissitude of governments, as well as governours, since whoever could get interest enough in the soldiery, or the multitude, would quickly devise and impose such a frame of government, as may put the management of affairs into his and his party's hands, and give them the authority, that have the power. But (resumes *Eusebius*) I must remember, that not politicks, but divinity is my profession, and therefore without enlarging upon the confusion that is inevitable in a state, where the right of governing being not heeded, or at least not ascertained, every man would pretend to counsel or command, and none would think himself bound to obey; I shall only mind you, that magistracy having been instituted by God for the good of mankind, we may in obeying our lawful magistrates, though perhaps less wise than we could wish them, not only participate the advantages naturally accruing from obedience to superiors, but divers peculiar blessings, that God oftentimes vouchsafes to our obedience to his vicegerents, and his institutions. Let subjects therefore (says *Eusebius*) wish for wise princes, but submit to those, the providence of God, and the laws of their country, may have given them: let us, if by any just way we be called to it, assist a prince with the wisest counsels we can; if not, let us assist him to make the best of the unwise counsels he has taken, without adding our factiousness or our passions to his misgovernment; remembering, that, at least in my opinion, to the happiness of a commonwealth it is not only requisite, that the prince know how to command well, but that the subjects obey well; and that even weak counsels, faithfully assisted, and as much as may be rectified or repaired by those, that are to execute them, may less prejudice the publick, than the forward and jarring endeavours of men, that perhaps would be wiser rulers, if they had a right to be so. It may be (continues *Eusebius*) that affection and diligence in the publick service may, in spite of the government's miscarriages, prevent, or at least retard and lessen, the ruin of the state. But however, (concludes he) it will be no small satisfaction to an honest man, and a loyal subject, not to be conscious to himself of having contributed to the publick calamities, either by his own provocations, or his factious indignation at the prince's faults. If a man have done his utmost to hinder the ruin he comes to be involved in, the publick calamity will be far lighter to him, being not clogged by private guilt; and he will support the misfortune of it with far the less trouble, if he be to support nothing else. Nay, since the service we do to whatever prince is rightfully set over us, upon the score of his being God's vicegerent, is ultimately directed to that supreme, and, as the scripture calls him, only potentate, whose magnificence is as inexhausted as his treasure; we may safely expect, that whatever prejudice we here

sustain upon the account of the prince's commands, will hereafter be advantageously considered to us in the reward of our obedience.

DISCOURSE XII.

Upon clouds rising out of the sea, and falling down in rain not brackish.

THIS discourse had already lasted so long, that as well my unwillingness, that one theme should detain us any longer, as my desire to keep *Eugenius* from making any reply, which on such an occasion might, perchance, have begot some dispute, made me forward to divert the discourse, by inviting the company to take notice of a black cloud, that was coming towards us; which soon after, in its passage under the sun, interposed betwixt our sight and that gloriouslest object of it. *Lindamor* then having a while attentively enough considered it, took thence an occasion to say, This cloud, gentlemen, whensoever it shall fall down in rain, will sufficiently shew, that it was before but water, which whilst it lay mingled with the rest of the river, or sea, whence it is exhaled, may be supposed as clear and limpid as any of the rest; but now that the sun has by its powerful beams elevated this water in the form of vapours, and drawn it near it self, we see, it composes a cloud, which does no longer receive or transmit the light, but robs the earth of it, and eclipses the sun that raised it; and sometimes too produces dismal storms of rain, and wind, and hail. Thus (pursues *Lindamor*) there are many, who while they continued in a low and private fortune, were as blameless as others; and yet, when by a peculiar vouchsafement of providence, they are raised from that humble state to a conspicuous height, they seem to have as much changed their nature as their fortune; they grow as much worse than meaner men, as their condition is better than that of such; and the principal things, by which they make their exaltation be taken notice of, are, the prejudice they do to their inferiours, and the ingratitude they excuse towards that monarch of the world, that raised them above others. Of so perverting a nature is so high a station, that the gaining of an earthly crown is very far from being a furtherance to the acquiring of an heavenly one; and many, whom an humble condition of life kept as innocent as lowly, are, by the highest advancement in point of fortune, impaired in point of morality; and these supreme dignities, which the ambitious world so fondly courts and envies, do so often manifest those, that have attained them, to be unworthy of them.

I know not whether *Eugenius* imagined, that *Lindamor* did in this discourse make some little reflection upon what we had lately said on the behalf of princes: but I afterwards suspected, that it was partly to reply to this observation, as well as entertain the company with a new one, that he subjoined; as this cloud has furnished *Lindamor* with one reflection, so that, which lately brought us the shower of rain, whose marks are yet upon our hats, may supply us with another, which may shew, that themes of this nature are applicable to very differing purposes, according as one or the other of their circumstances happens to be considered and employed: for as far (pursues he) as we can judge by the neighbourhood of the sea, and by that cloud's being driven hither by a wind blowing thence, it consisted of the sea-water raised in the form of vapours. But though the water of the ocean is salt and brackish, unpleasant and unwholesome, whilst it lies there unelevated; yet that water, which has the advantage of being raised to the second region of the air, appears, when it is turned into rain, to have left all its brackishness behind it, and proves both wholesome for men's bodies, and fertilizing to their fields.

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THUS (continues *Eugenius*) we sometimes see, that men, who in a private condition were subject to divers vices, divest them, when they are advanced to the honour of putting on royal robes; as silk-worms leave their husks behind them, when by acquiring wings they turn into (a nobler sort of creatures) flying animals. As most men change, so some improve their minds with their condition, and seem to have misbehaved themselves in a lower station; but because they were born to a higher, and were, whilst beneath it, detained out of their proper sphere. And indeed, as a throne exposes those that sit on it to peculiar temptations to vice, so does it afford them peculiar engagements to virtue; as so elevated a station is apt to make men giddy, so is it proper to make them circumspect, by letting them see, that all the world sees them: the sublimity of such a condition would make any soul, that is not very mean, despise many mean things, that too often prevail upon inferior persons. If princes have any sense of shame and honour, it will be a great curb to them, to consider, that, as there are too many eyes upon them to let their vices be secret, so their faults can as little escape censure as discovery; and men will be the more severe to their reputations, because it is the only thing, wherein subjects can punish their sovereigns. If they have any thing of generosity in their natures, their very condition, by placing them above other objects, will make them aspire to glory; and that is a mistress, that even monarchs cannot successfully court, but with great and good actions. And if they have withal a sense of piety, they cannot but in gratitude to him, whose vicegerents they are, endeavour to promote his interests, that made them so; and so make themselves as like him as they can, in his other attributes of clemency, justice, and bounty, as he has vouchsafed to make them in his power and authority. And besides, that the actual possession of an earthly crown leaves them nothing worth aspiring to, but a heavenly one; the consideration of the great advantages they have above other men of doing good, and the exemplariness and influence as well of their vices as of their virtues, will make them tremble at the thoughts of the account they must one day render of so many thousands, perhaps of so many millions (of subjects) committed to their charge; if, as they are sure it will be a great one, they shall not make it a good one. Nor (pursues *Eugenius*) is history altogether unfurnished with examples of those, whom a throne has as well improved as dignified. *Saul* was not the only person, who, when he was created king, had another spirit, and became another man. That *Titus*, who was the head of it, was justly styled the darling of mankind, though his virtue and nobleness did, more than his crown, keep the greatest part of posterity from taking notice of any thing in him, but an obligingness proportionate to his greatness; yet I find in some ancient writers, to whom truth was more dear than even this favourite of mankind, that before he came to that supreme pitch of human dignity, his course of life did not promise the Roman world the happiness it derived from his government; his life, before he came to be Emperor, having not been so free from blemishes of lust and blood: but that I may, in writing his character, invert what the Roman historian said of one of his predecessors, and say, that *Titus* had been thought *indignus imperio, nisi imperasset*. And, without going as far as *Rome*, our own history affords us a *Henry* the fifth, who, before he came to the kingdom, was scarce thought worthy to live in it, and did so degrade himself to the practices of the meanest malefactors, that a judge, that was then his father's subject, was fain to use him at that rate; and yet this prince, as soon as he had seated himself in the throne, did as suddenly, as if the place itself had some secret virtue to improve those it admitted, behave himself as a person worthy of it; and not only conquered *France*, but, which was a nobler, as well as a more difficult victory, his own resentments too, by preferring that judge, when king, that had imprisoned him, when prince; and evincing by

† Sam. x.
6, 9.

so memorable an action, that he preferred virtue above himself, and renouncing the pleasure of revenge, he scrupled not to promote one, whom he could not commend without condemning himself; were it not, that in this prince, according to what I was saying, the king was become another man than the subject. And perhaps, (concludes *Eugenius*, a little smiling) I could proceed to give you other examples enough to keep it from being improbable, that one main reason, why there are but few good princes, is, because there are but few princes; were it not, that I see the waterman prepare to land us. And in effect, we are now come so near the place, where the fisherman designed to set us ashore, that whether or no *Lindamor* had a mind to return any thing to what *Eugenius* had said, it would then have appeared unseasonable, either to resume the debate, or prosecute the discourse.

DISCOURSE XIII.

Upon drawing the boat to the shore.

WHEN we were now come to the place, where we were to be landed, left the boat should be carried away by the stream before we could step ashore, the owner of it reached out his long pole, and by means of the crook, taking fast hold of the bank, he drew the pole towards him with all his might, and thereby brought the boat to shore. This endeavour of the water-man's, and the effect of it, inviting *Eusebius* to smile a little, gave me the curiosity, as soon as we were landed, to inquire, why he did so. It is almost as ordinary (answers *Eusebius*) for men to think themselves wiser than God, as it is impossible for them really to be so. Those, that study nothing but to obtain their ends, and that scruple at nothing they judge conducive to them, do oftentimes lay their designs and plots with so much artifice and subtilty, that they do not doubt, that, whatever may become of God's designs, and of his promises, and threats, those, which themselves have laid so politickly, cannot but succeed. And even pious and well-meaning persons, that have the opportunity to discern the politick ways, that these men take to compass their ends, are oftentimes tempted to needless fears, that divine providence will be puzzled and distressed by them; and to think, that, for reasons secret, though just, providence may be put by these men's craft to play an after-game in the world to come. But in such cases, it often fares with these grand designers, as it did just now with our water-man: he had fastened his grappling-iron to the shore, and putting to his utmost strength, did so forcibly endeavour to draw it towards him, that one, that did not know that the shore was fixt, might expect this lusty fellow's endeavours capable to put into motion whatever he so forcibly drew towards him: but the shore being fixt, and immoveable, instead of making that come to him, his very strainings drew him and his boat to that. Thus the contrivers of the proud pile of *Babel*, whereby they meant (not as most imagine, to secure themselves against a second flood; the text being silent as to that aim, and a plain being a very improper place for such a purpose, but) to make themselves a name, and prevent dispersion; these ambitious contrivers, who had laid their plot so hopefully, that they had engaged no less than mankind, and who probably had designs as raised as their intended fabrick, since those expressions of him, that knew their hearts, (*And this they begin to do, and now nothing will be restrained from them, which they have imagined to do*) seemed, methinks, to warrant my conjecturing, that those had designs very aspiring, that intended but to make a rise to their soaring flight of a tower, whose top should reach unto heaven. But the policy of these ambitious builders being contrary to the charitable decree of God, to have the earth peopled, he made use of that very conspiracy, that brought them together, to effect that,

Gen. xi. 6.

which they conspired to prevent; so that now the remotest parts of the inhabited world are but the colonies of *Babel*, whose scattered architects have indeed made themselves a name, but upon a quite contrary account than they intended or expected. Thus the purblind envy of *Joseph's* brethren, having made them resolve to prevent his future dreams of superiority over them, made them think, that, by selling him for a slave, they had taken sufficient order he should never come to be their master. And yet we see, that *Joseph's* being sold into *Egypt* was made use of by the wise orderer of human affairs, to make him in effect Lord of that rich and populous kingdom, and thereby, of his envious brethren, *Pharoah's* dreams having advantageously made him amends for the hardships his own had exposed him to. So the proud favourite of *Abasuerus*, questionless, thought he could scarce miss his ends, when, by the counsel of his friends, and, as he fondly thought, of his gods too, he provided for *Mordecai* that fatal gibbet, which probably he might have escaped, if he had not erected it. Thus the high priest, and the sanhedrim of the Jews, seemed to act with much policy, though no justice, when they resolved upon the death of our Saviour; lest, as the Gospel tells us, the Romans should come and destroy their temple, and nation; which, whether indeed it did not rather procure, than divert the coming of the Romans, the church-history can inform you. Nay, the old serpent himself, that arch-politician, that was the instructor of those others I have been naming, even in his chiefest master-piece, found himself the most over-matched by him, to whom the Scripture ascribes the taking of the wife in their own craftiness. For, questionless, he highly applauded his own subtilty, and seemed to have taken the directest, and most prosperous way to his impious ends, that could be devised; when, having made *Herod* and *Pilate* friends, upon such terms, that the Lamb of God should be the victim of their new confederacy, he had engaged both Jews and Gentiles in a ruinous and tragick conspiracy, to kill the prince of life, and, by that unparalleled crime, at once destroy the devil's chief enemy, and make God their's. And yet the event has sufficiently manifested, that the Apostle might well affirm, that Christ, by his death, destroyed him, that had the empire of death, the devil; and that Satan's kingdom never received so deadly a wound, as that which pierced our crucified Saviour's side. Wherefore, in short, (concludes *Eusebius*) the decrees of providence are too solid and fixed, to have violence offered them by human attempts, how specious soever they be; and those, that think to bring God to their bent, will find, at long running, that they have to do with one, whose power and wisdom are so overruling, that not only he can frustrate their utmost endeavours, but make those very endeavours frustrate themselves, and employ men's subtlest policies, to accomplish those very things they were designed to defeat.

DISCOURSE XIV.

Upon catching store of fish, at a baited place.

AS soon as we were come to the place the fisherman told us of, we found it as plentifully stored with fish, as he had foretold us; and caught more in some few minutes, than we had taken in a whole hour before: but we did not half so much marvel at this, as we were pleased with it, because the fisherman informed us, that he had liberally baited the place over-night with corn, as well as worms. Whilst this pleasant exercise lasted, *Eusebius*, marking how great a resort of fishes there was in that place, and how fast we drew them up, upon comparing what he saw happen with the occasion of it, thus acquainted us with the thoughts thereby suggested to him. Those (says he) that yesterday in the evening might see this man

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(pointing at the fisherman) throw in his baits by handfuls into this place, and then depart, as minding them no more, were probably, if they knew not his design, and the custom of fishers, tempted to think him a wasteful prodigal, or, at best, a venturesome fool, to bury his corn in the river, and throw his baits to be caught up by fishes, that, for aught he knew, would never come back to thank their host. But those, that know (what we now find) how profitable a course this is wont to prove, would, instead of thinking such a practice a piece of folly, look upon it as a piece of providence: for though he be sure not to recover, in kind, the things he cast upon the waters, yet such a loss is wont to prove very gainful unto him, whilst he loses but a grain of corn, or a worm, to obtain fishes of far more value. Thus, though the purblind world may think a liberal alms-giver, or a generous confessor, a fool, or a prodigal, whilst they only consider him as one, that throws away what he has in present possession, and seems not so much as to hope for the recovery of the same goods, or any of the like nature; yet those, whose eyes being illuminated with a heavenly light, are thereby enabled to look into the vast and distant regions of the future, and to descry there the final issues of all temporal things, will be so far from thinking him unwise, for parting with unsatisfying trifles, to procure the highest and most permanent goods, that they will think his proceedings far more justifiable, in point of prudence, than we now think the fisherman's: nor will the parting with a greater fortune, as freely as with a lesser, any more alter the case, than the fisherman's throwing in his bigger worms, and grains of corn, with no more scruple than his lesser. For heaven does as well incomparably out-value the greatest, as the least goods, poor mortals can lay out for it; and he, who has all things to give, and is infinitely more than all himself, has promised, that those that sow plentifully, shall reap so too; and though the least of future acquits would incomparably transcend the greatest price, that can be here given for it, yet the future rewards will, betwixt one another, bear a proportion to the occasions of them. And, as the fisherman is sure to lose what he throws into the water, and is not sure to get by it any thing of greater value than some fishes, the Christian adventurer (if I may so call him) may hope, though not confidently promise himself, in this world, the hundred-fold mentioned by our Saviour, as well as in the world to come life everlasting. And therefore, if we do indeed, in *St. Paul's* language, look, not to the things, which are seen, which are but temporary, but to the invisible ones, which are eternal, we shall think that exhortation of his very rational, as well as very pious, where, having discoursed of the future and glorious state of the true Christians, he concludes, *Wherefore, my beloved brethren, be ye steadfast, immoveable, always abounding in the work of the Lord; for as much as you know, that your labour is not in vain in the Lord.*

DISCOURSE XV.

Upon the magnetical needle of a sun-dial.

WE had not yet dismissed the waterman, when *Eugenius*, chancing to express a curiosity, to know what o'clock it was, when we had freshly begun to angle at our new station; as *Lindamor* and the rest drew their watches to satisfy his question, so the boat-man took out of his pocket a little sun-dial, furnished with an excited needle, to direct how to set it, such dials being used among mariners, not only to shew them the hour of the day, but to inform them from what quarter the wind blows. Upon the sight of this dial, my natural curiosity invited me, after it had told me the hour, to try, whether the magnetick needle were well touched, by drawing a little penknife out of a pair of tweezes I then chanced to have about me, and approaching it to the north point of the needle, which, according to the known custom

of such needles, readily followed it, or rested over-against it, which way soever I turned the penknife, or whereabout soever I held it still. *Eusebius* seeing me give my self this diversion, came up to me to be a sharer in my sight, which no familiarity can keep from being a wonder: but, after a while, he looked upon it in a way, that made me think it presented him somewhat else than the hour of the day, or the corner of the wind; and I was confirmed in that thought, by seeing him apply to it the case of *Lindamor's* watch, and then a diamond-ring, plucked from his own finger, and, in effect, he soon began to tell me; Methinks, *Philaretus*, this needle may afford us a good direction in the choice of companies; and that is a matter of such moment, that some divines perhaps would question, whether or no the direction it gives navigators, to find the poles, be of much greater importance. For not only it has been truly observed, that the choice of one's company does exceedingly discover, whether a man be good or bad, wise or foolish; but I shall venture to add, that it does very much contribute to make him what others say it declares him: for an assiduous converse does insensibly dispose, and fashion our minds and manners, to a resemblance with those we delight to converse with; and there are few, that have so much resolution, as to disobey customs, and fashions, especially when embraced by persons, that we love, and would be esteemed by, and from whose opinions, and practices, we can scarce dissent constantly, without impressing a dislike, that threatens to make them dislike us. For my part, (says *Lindamor*) I have always thought, there is great difference betwixt keeping company with some men, and chusing to do so; for, whilst we live in this world, we must often have to do with the lovers of the world: but though to be cast, by the exigencies of our callings, upon bad company, be an infelicity without being a fault, yet certainly, to chuse such company, and prefer it before that of wise and good men, is, in a high degree, both the one and the other. And I confess, (continues he) I cannot think, that the proper use of conversation is but to pass away our time, not to improve it.

You are certainly much in the right (subjoins *Eusebius*) for though too many of those, that are now cried up for good company, do either so dissuade us from good and serious things, or so divert us from them, that it is oftentimes counted a piece of indiscretion, to say any thing, that may either enrich men's understandings, or awaken their consciences; yet I cannot but think, that conversation may be, as well as ought to be, rescued from being an instrument to promote idleness and vice: and, if men were not wanting to themselves, I doubt not, it may be so ordered, that conversation, which so often robs men of their time, and so frequently of their devotion, might be made a great instrument of piety, and knowledge, and become no less useful, than it is wont to be pleasant.

To make companies (replies *Lindamor*) such as you think they may be, they must grow very different from what most commonly they are: for, not to speak of those loose and profane ones, where virtue and seriousness are openly derided; and any thing, how contrary soever to piety, or right reason, may be used, not only with toleration, but applause, if men can bring it out, I say not in jest, (for they are seldom more in earnest) but neatly wrapt up in raillery; even in those civiler sorts of company, where vice is not professedly maintained, you shall seldom, during a long stay, hear any thing, that is really worth carrying away with you, or remembering when you are gone. And, to discourse of any thing, that is grave enough, either to exercise men's intellects, or excite their devotion, is counted a piece of indiscretion, that is wont to be more carefully avoided, than almost any thing that is really such; so that, even in such companies, the innocentest use, that we are wont to make of our time,

time, is to lose it. And really (continues *Lindamor*) when I consider, how ensnaring the worse sort of companies are, and how little even those, that do not openly defy piety and knowledge, are wont to cherish either of them; I begin to be reconciled to hermits, who fly from such conversations, as are so apt to make men either vicious, or at least idle, into those solitudes, where they are not like to be tempted, either to renounce their devotion, or to suppress it, to entertain idle thoughts, or stifle good ones. Nor could I, without much scruple, as well as impatience, allow my self to spend some part of my time in such kind of entertainments, as many spend most of their's in, were it not, that looking upon civility as a virtue, and hospitality, as in some cases a duty, and upon both of them as things of good report, I can think those hours, they make me spend, may be justly cast upon their account, and that the ceremonious and insignificant conversations, whereto they oblige me, may be undergone upon some such account, as that, on which serious parents converse, and often-times play with their children. For as, though the things they do, are in themselves trivial, and useless, yet they may be justifiable effects of a paternal care to still a child, or keep him from harming himself; so the duty of exercising of civility makes me look upon as justifiable, though unpleasant, those expressions of it, which in themselves considered, I could not reflect on without indignation, and could not but think very much below any man, whom education has fitted for the exercise of reason, or whom religion has elevated to the hopes of heaven.

BUT it may (says *Eusebius*) on the other side be represented, that since it is scarce possible not to meet sometimes with companies, that are not of the best sort, we should look upon those necessities, as calls of providence, to improve those opportunities for the advantage of them we are engaged to converse with: for nature, as well as Christianity, teaches us, that we are not born only for ourselves, and therefore, as we ought often to converse with the best men, to acquire virtue and knowledge; so we must sometimes converse with others, that we may impart them, and learn how much we are beholden to God's goodness, that has so much discriminated us from other men. And though we do not find, that our conversation does immediately and visibly reform those we converse with, yet it will not presently follow, that it is altogether ineffectual on them: for, besides that the seeds of virtue and knowledge, as well as those of plants, may long seem to lie dead, even in these soils, wherein they will afterwards flourish and fructify, there may be at present a good, though not a conspicuous, effect of your discourse and example. For when men are hasting to hell, he does them no small service, that does so much as retard their course; as cordials, and other medicines, may do good even to decrepid old men, whom they cannot perfectly cure.

AND trust me, *Lindamor*, it is no such useless performance as you may think it, for a man of known piety and parts, by conversing with the children of this generation, to dare to own religion among those that dare to deride it; to keep alive and excite a witness for God and good things in their consciences; to let them see, and make them (at least inwardly) acknowledge, the beauty of a pious, industrious, and well-ordered course of life; to convince them, that it is not for want of knowing the vanities they doat on, that he despises them; to shew, that a man that denies himself their sinful jollities, can live contented without them: and, (to dispatch) to manifest, by a real and visible demonstration, that a virtuous and discreet life is no unpracticable, no more than melancholy thing, even in bad times, and among bad men. And, says *Eusebius*, to me it seems very considerable, that our Saviour himself, the great author of our faith, and exemplar of our piety, did not chuse an anchorite's, or a monastick life, but a sociable and an affable way of conversing with mortals, not

refusing invitations, even from publicans, or to weddings, and by such winning condescensions gained the hearts, and thereby a power to reform the lives, of multitudes of those he vouchsafed to converse with.

OTHER considerations (pursues *Eusebius*) might be represented to the same purpose with these: but since I promised you something of direction, I suppose you will expect I should tell you not what I *could* say, but what I *do* think. I will tell you then in few words, that though I think it as well possible as fit for men of radicated virtue, and fine parts, to make sometimes a good use of bad company, especially when their lawful occasions cast them into it: yet, for others to be often engaged in such company, though it may be but an infelicity, is a very great one; and to chuse such company, is, what is worse than an unhappiness, a fault. But generally speaking, I would distinguish three sorts of companies: for there are some, that not only are unable to improve me, but are unwilling to be improved themselves. A second sort there is, that are as well ready to learn, as able to instruct: and there are others, that, though they are not proficient enough to teach me things worth my learning, are yet desirous to be taught by me the little, that I know, and they ignore. Now, as the magnetick needle we were looking on, and which affords us the theme of this discourse, if you should apply a load-stone to it, would be most powerfully attracted by that, because it can receive fresh virtue from it; and even, if you approach a piece of steel to it, the needle will, though not so studiously, apply itself to it, from which, though it receives no magnetick virtue, it can impart some to it; but if you offer it the silver case of your watch, or the gold, that makes up your ring, or the diamonds that are set in it, none of all these, how rich or glittering soever, will at all move the needle, which suffers them to stand by it unregarded: so I shall, with the utmost cheerfulness, and application, seek the company of those, that are qualified to impart to me the virtue or the knowledge they abound with. Nor shall I refuse to entertain a society with those few, that being such small proficient as to need to learn of me, are also forward to do so. But those, that can neither teach me any thing, that is good, nor are disposed to let me teach them, how great a shew soever they make among those, that make choice of their companions by their eyes; I may be cast upon their conversation, but shall very hardly chuse it.

DISCOURSE XVI.

Upon the quenching of quick-lime.

I HAD almost forgot to relate, that not far from the place, where we went on shore, and which we had not yet quitted, we saw divers heaps of quick-lime, some smoking, and some, that had not yet been drenched in water; and upon inquiry of those, that looked to it, we were soon informed, that the conveniency of the neighbouring river, both for slacking of lime, and conveying mortar, had made the owners bring their lime thither, to be tempered and made fit for the reparation of some houses, that we saw a little way off: but while we were talking, one of the workmen began to throw water upon one of the heaps, that had not yet been slacked, and afterwards poured on so much more as served quite to drown the lime; and *Eusebius* marking, both what he did, and what ensued upon it, took thence occasion to say to us; he, that should see only the effect of the first effusion of cold water upon quick-lime, would think, that by a kind of antiperistasis, the internal heat of the lime is rather increased than suffocated by the coldness and moisture of the water: for that, which before was not taken notice of, to manifest any sensible warmth, as soon

as its enemy, the water, begins to invade it, acquires a new heat and new forces in the conflict, and not only shews a great impatience, or enmity, to that cold liquor, by acting furiously upon it, and throwing off many parts into the air, but prevails so far as to heat that cold element itself, to that degree, as to make it smoke and boil. But this conflict is seldom near so lasting as it is eager; for if you have but the patience to stay a while, you shall see the lime, after it has spent its occasional ardour, and after its fire is quenched, lay quietly with, nay under, the water, as cold and as moveless as it. Thus, when a devout man (especially if his fervour be adventitious from education, or custom, as the fire in the lime from the calcination) first falls into the company of persons, either profane, or otherwise grossly vicious, we often see, that his zeal, instead of being smothered by such a rude and unaccustomed opposition, seems rather to be excited and kindled thereby, and possibly seems more likely to impart the warmth of his devotion to its enemies, than to lose any of it himself; but when he is constantly, or at least frequently, surrounded with such company, you will too often see him lose as well his own ardour as the endeavours of communicating it; and with those very persons, that did at first kindle and exasperate his zeal, you shall at last see him live very quietly, and perhaps manifest as little of religious warmth as they; and that, which at first did so strangely exasperate and discompose him, becomes after a while so familiar, as not at all to move him.

DISCOURSE XVII.

Upon one's talking to an echo.

WE had possibly dwelt longer upon such reflections, had I not been suddenly diverted by the repeated clamours of a voice, which each of us imagined he had very often heard: whereupon, as it were by common consent, we began to look round about us, to see if any of our little company were missing; and finding that *Eugenius* was so, we readily concluded the voice we heard, though somewhat altered by distance, and other circumstances, to be his; and accordingly we hastened towards the place, whence we judged the voice to proceed, that in case he were in any distress, or had met with any disaster, we might rescue or relieve him: but when he came near, we could now and then distinctly hear him speak some words so loud, and yet so incoherent and unable to complete a sense, as if he meant, that all thereabouts should hear him, and no body understand him. This made us double our curiosity, and our pace, till at length we descried him all alone in a solitary corner, wherein yet his loudness kept us from believing he sought privacy: but as soon as he discovered us, he seemed both surprized and troubled at it. Coming to meet us, he first begged our pardon, if having been louder than he thought, he had put us to a trouble he did not intend; and then laughing, asked us, if we did not think him mad: but *Eusebius* smiling told him, that before we could answer that question, we must ask one of him, which was, what he had been doing? Whilst you, (answers *Eugenius*) were (I doubt not) better employed, my natural curiosity seduced me to spend some time in ranging about the places near the river-side; and as I was passing by this field, the accidental lowing of an ox made me take notice, that this neighbouring hill and wood furnish this place with an excellent echo, which I at first tried only by whooping and hollowing; but afterwards diverted my self by framing my questions so, as to make that babbling nymph (for so you know the poets will have Echo to be) to discourse with me.

For

For my part, (says *Lindamor*) I should by no means like her conversation, because that two qualities she has, which to me would very much discommend it: and to prevent our asking him what those qualities were, one of them, (says he) is, that she vouchsafes to discourse indiscriminally with all comers that talk to her, provided that they make noise enough.

You are much in the right, (says *Eugenius*) for that easiness of admitting all kind of company, provided men have boldness enough to intrude into ours, is one of the uneasiest hardships, (not to say martyrdoms) to which custom has exposed us, and does really do more mischief, than most men take notice of; since it does not only keep impertinent fools in countenance, but encourages them to be very troublesome to wise men. The world is pestered with a certain sort of praters, who make up in loudness what their discourses want in sense; and because men are so easy-natured, as to allow the hearing to their impertinencies, they presently presume, that the things they speak are none; and most men are so little able to discern in discourse betwixt confidence and wit, that like our echo, to any that will but talk loud enough they will be sure to afford answers. And, (which is worse) this readiness to hazard our patience, and certainly lose our time, and thereby encourage others to multiply idle words, of which the Scripture seems to speak threateningly, is made by custom an expression, if not a duty, of civility; and so even a virtue is made accessory to a fault.

For my part, (subjoins *Eugenius*) though I think these talkative people worse publick grievances than many of those, for whose prevention, or redress, parliaments are wont to be assembled, and laws to be enacted; and though I think their robbing us of our time as much a worse mischief than those petty thefts, for which judges condemn men, as a little money is a less valuable good, than that precious time, which no sum of it can either purchase or redeem; yet I confess, I think, that those of our great lords and ladies, that can admit this sort of company, deserve it: for if such persons have but minds in any measure suited to their qualities, they may safely, by their discountenance, banish such pitiful creatures, and secure their quiet, not only without injuring the reputation of their civility, but by advancing that of their judgment. And I fear, (continues *Eugenius*) that those, who decline this employment (and indeed improvement) of their titles, or other kinds of eminency, do, by their remissness, more harm than they imagine; for though the judgment and company of such persons be not always the best grounded, or the best chosen, yet their quality or station in the world makes it usually the most conspicuous, and the most considered. And I doubt not, there is no such multitude of disinterested lovers of good things, but that there will be the fewer found studious to express wit and virtue in conversation, when they see, that in the estimate of those, that are looked upon as the chief judges of what is or is not good company, the most empty and impertinent prattle with confidence, or loudness, procures a man at least as good a reception, as the best and most rational discourse without it. And, which is yet worse, that tyrannous thing, which we mis-name civility, has so degraded reason, as well as displaced piety, in conversation, that if there be never so many persons together, entertaining themselves with rational or instructive discourse, in case there come in but one impertinent creature, that is below it, all these shall sink themselves to his level, and as much debase their discourse, as if they believed it fitter, that all the rational conversers should forego the exercise and the benefit of their wit and virtue, than that a fool should not appear to talk as wisely as any of them. And thus they seem ashamed of their attainments, instead of making him ashamed of his ignorance, and reducing him to improve himself into a capacity of being fit for their company; whereas, from a contrary practice, they

they might derive the great advantage, either of freeing themselves from uninvited companions, or of making them worth the having.

BUT, (subjoins *Lindamor*) I remember I told you there was a second quality, that I disliked in the nymph I found you entertaining, and that is, that, when I will, I can make her speak to me, just what I please. I know (replies *Eugenius*) that a moderate degree of complaisance is not only in many cases allowed us by discretion, but necessary to keep up the pleasantness, not to say the very peace, of human societies; for if all men, at all times, speak their minds freely, and did not soften one another by concealing their mutual dislikes, and dissents, and by certain outward expressions of kindness, or respect, made by compliments and gestures, men have so many imperfections, and so much self-love withal, that scarce any two of them would endure one another; nay, and in spite of that indulgence, which provident nature has implanted in all animals, for the preservation of their species, in that of the individuals that compose it, and as much as our own faultiness has added to that fondness; yet, I doubt, we shall scarce find one man of a thousand, that would endure so much as himself, if we did not for the most part exercise complaisance within our own breasts, and did not as much flatter our selves, and disguise our selves, to our selves, as we flatteringly disguise our selves to others.

BUT, (continues *Eugenius*) when all this is said, I may endure, but I shall scarce chuse and prize a companion, that, like an echo, uses no liberty of his own, but allows me to direct whatever I would have to be answered me: and I know not whether I could not better like one, that would ever dissent from me, than one that would never do so. I cannot look upon him either as my friend, or as a person worthy to be made so, who never evinces his being more concerned to advantage me, than to please me, by making use of the liberty of a friend, and thereby shewing, that he considers not barely himself, but me: besides, that as there is no true friendship, where there is not an union of affections, so methinks there can be no good company, where there is not sometimes a dissent in opinions.

EUSEBIUS, that was a friend to seriousness, without being an enemy to pleasantness, gathering from the long pause made by his friends, that they designed not the prosecuting of this discourse any further; Methinks, gentlemen, (says he, smiling) you are very severe to a harmless nymph, who is so modest, and reserved, that she will never put you upon beginning a conference with her, and so complaisant in it, that it is your own fault, if ever she says any thing to you, that displeases you: and for my part, (continues he) I have that opinion of human things, that as I think there are very few so perfect, but that we may find something in them fit to be shunned, so there are not many so imperfect, but that they may suggest to us somewhat or other, that may not be unworthy of our imitation; and as *Lindamor* has taken notice of two qualities in our echo, which discommended it to him, so I have observed as many, that I rather approve than dislike.

FOR, in the first place, it is evident, that our nymph (however *Eugenius* has been pleased to mis-call her a babler) is much less talkative than most of her own sex, or indeed of ours; for she never begins to talk with any body, not speaking unless she be spoken to. He that considers how much of the discourse, that wastes men's time, and entertains the most companies with the most applause, consists of talk, that tends either to flatter those that are present, or detract from the absent, or to censure our superiours, or our betters, or to express our own profaneness, or to excite the pride or carnality of others; and he that shall consider, that though by these and many other ways we are extremely apt to offend in words, yet we must give an account for that kind of words, what sort soever be meant by them, which our translators render idle ones;

VOL. II. I find that I have said more than I intended to say, and

and that the judge himself tells men, that they shall by their words, as well as by their actions, be justified, or condemned; will easily believe, that if silence were as much in fashion, as it is charitable to mankind to wish it, the regions of hell would be far thinnier peopled than now they are like to be.

I COULD tell you, that silence discovers wisdom, and conceals ignorance; and it is a property, that is so much belonging to wise men, that even a fool, when he holdeth his peace, may pass for one of that sort; and I could easily add I know not how much in the commendation of this excellent quality, if I knew how at the same time to praise silence, and to practise it: so that it may well pass for an excellency in the nymph, whose apology I am making, that she does not speak, but when it is necessary she should, I mean, when she is spoken to, in such way as does exact her answer.

BUT this is not all the good qualities of our echo; for as she rarely speaks, but when it is expected she should, so she seldom repeats above a small part of what is said to her: this I account a very seasonable piece of discretion, especially in such treacherous and fickle times as ours, where, almost as if he thought himself fit to be an universal statesman, such a one concerns himself very needlessly for almost all the publick quarrels in Christendom, and shews himself zealous for a party, which will receive no advantage by his disquiets; and not content like a merchant-venturer, his passion may upon this account make him a sufferer by what happens in the remotest parts of the world. In our own fatal differences, (which it is almost as unsafe to speak freely of, as it is unhappy to be involved in them) he will on needless occasions declare, with his opinion, his want of judgment, and perhaps ruin himself with those, under whose protection he lives, by spreading reports, and maintaining discourses, that rendered him suspected among those, who think, that a man must with their forces should be beaten, if he can think they may have been so: nay, I have known some, that, though put into considerable employments, could not hold talking of their own party, at a rate of freedom, which those that have so much innocence as not to deserve it, will scarce have so much goodness as to support it. So that methinks, these men deal with their fortunes as children oftentimes do with their cards, when having taken a great deal of pains to build fine castles with them, they themselves afterwards ruin them with their breath.

It may be a greater, without being a more prejudicial piece of folly, to believe all that one hears, than to report all that one believes; and especially, those are to be censured for want of our nymph's reservedness, by whom it loses that name: for though those kind of men make sure, by their way of talking, to make others take notice, how much they are confided in by their own party, yet sure they would take a discreeter course, if they did but consider, that the proof they give, that they are trusted with secrets, is, that they are unfit to be so.

DISCOURSE XVIII.

Upon a giddiness occasioned by looking attentively on a rapid stream.

THESE thoughts of *Eusebius* suggested so many to *Lindamor*, and me, that to entertain our selves with them, we walked silently a good way along the river side; but at length, not hearing any more the noise his feet were wont to make in going, turning my self to see what was become of him, I perceived him to be a pretty way behind me upon the river's brink, where he stood in a fixt posture, as if he were very intent upon what he was doing. And it was well for him, that my curiosity prompted me to see what it was that made him so attentive; for, before I could quite come up to him, methought I saw him begin to stagger, and though that sight added wings

wings to my feet, yet I could scarce come time enough to lay hold on him, and, by pulling him down backwards, rescue him from falling into the river. The shriek I gave at the sight of my friend's danger, was, it seems, loud enough to reach *Eusebius's* ears; who, turning his eyes towards the place whence the noise came, and seeing *Lindamor* upon the ground, made hastily towards us, and came up to us by that time I had helped *Lindamor* up, and before I had received from him the obliging acknowledgments he was pleased to make for a piece of service, that I thought had in it more of recompense than merit. *Eusebius* hearing what passed betwixt us, joined his thanks to *Lindamor's*, and at the same time congratulated my friend for his escape, and me for having, to use his expressions, had the honour and satisfaction to be such a person as *Lindamor's* deliverer. But after our expressions of joy for his escape were over, *Eusebius* and I had both a curiosity to learn particularly the occasion of his danger, which he told us in these words: As I was thinking, *Eusebius*, on your last reflection, I was diverted from prosecuting my walk in *Philaretus's* company, by happening to cast my eyes on a part of the river, where the stream runs far more swiftly, than I have all this day taken notice of it to do any where else, which induced me to stop a while, to observe it the more leisurely: and coming nearer, I found the rapidness of the current to be such, notwithstanding the depth of the water, that I stood thinking with myself, how hard it were for one to escape, that should be so unlucky as to fall into it. But whilst I was thus musing, and attentively looking upon the water, to try whether I could discover the bottom, it happened to me, as it often does to those that gaze too stedfastly on swift streams, that my head began to grow giddy, and my legs to stagger towards the river; into which questionless I had fell, if *Philaretus* had not seasonably and obligingly prevented it. Something like this (says *Eusebius*) does not unfrequently happen in the unwary consideration of some sorts of sinful objects, especially those suggested by atheism and lust: for not only we oftentimes consider atheistical suggestions, and entertain libidinous fancies, without any intention to quit our station, or the secure and solid basis of religion and chastity; but we are often inclinable to think, that we converse with these objects only to discern their formidableness the better, and fortify our resolutions to shun them. And yet such is the pernicious nature of atheism, and of lust, that they turn our brains, and oftentimes, if providence, or Christian prudence, do not seasonably interpose, we may unawares fall into the mischief, even by too attentively surveying its greatness, and may be swallowed up by the danger, even whilst we were considering how great it is. To parly with such fascinating enemies, though with a design to refuse them, and strengthen our aversion to them, is against the laws of our Christian warfare; and though it be not as criminal, may often prove as fatal, as to hold intelligence with the enemy. It is true, that the deformity of both these sins is such, that all their ugliness cannot be taken notice of at first sight; but the discovery is more dangerous than necessary, since a little knowledge of their hideousness is enough to make every honest heart abhor them. And since their less obvious deformities are more dangerous to be pried into, than necessary to be known, let us fear to learn of these deluding sins, more than we need know to hate them; and remember, that even those, that are frightened by seeing faces recently marked with the small pox, may, notwithstanding that fear, catch the disease with that sight.

DISCOURSE XIX.

Upon one's drinking water out of the brims of his hat.

WE were by this time come back to the baited places we had left, when *Eugenius*, to whom his rambling up and down, added to the heat of the day, had given a vehement thirst, spying a place, where the banks were low, and almost level with the surface of the water, left us for a little while to repair thither; and kneeling upon the ground, he took up with his hat, which by cocking the brims he turned into a kind of cup, such a proportion of water, that he quenched his thirst with it; and carelessly throwing the rest upon the ground, quickly returned towards the company, which he found he had not left so silently, but that our eyes had been upon him all the while he was absent: and that sight afforded *Eusebius* an occasion to tell us, our friend *Eugenius* might, if he had pleased, by stooping lower with his head, have drank immediately out of the entire river. But you see he thought it more safe, and more convenient, to drink out of a rude extemporary cup; and that this way sufficed him fully to quench his thirst, we may easily gather, by his pouring away of some remaining water as superfluous: and if he should tell us, that he could not have quenched his thirst with a sufficient quantity of water, because he drank it not out of the river, but out of his hat; I doubt not, you would think him troubled with a more formidable distemper than thirst, and conclude him in a greater need of physick than of water.

Thus (resumes *Eusebius*) to a sober man, provided he have a competency of estate suited to his needs and conditions, it matters not very much, whether that competency be afforded him by a moderate or by an exuberant fortune, and oftentimes it is more safe and convenient, and no less satisfactory, to receive this competency out of that, which is but a little, than out of that, which is a great deal more than enough; for not only the necessities of nature are few, but her capacities are limited. And therefore, how much soever you have of meat, and drink, and the like accommodations; the body of a man can enjoy but a certain, and that too no very great measure of them, proportioned to the craving of our stinted nature, by more than which it is not the body, but the unruly fancy, that is gratified; as when the stomach is satisfied, a table full of untouched dishes feeds but a man's eye, or his pride; and if he should cram a little part of it into his stomach, it would be but nauseated at first, and afterwards breed ill humours and diseases. And accordingly, it is no less than *Solomon* that says, *when goods increase, they are increased that eat them; and what good is there to the owners thereof, saving the beholding of them with their eyes?* I dare not absolutely (pursues he) condemn those, that think not the necessities of nature the only measures of a competency of fortune: for though he, that wants not them, wants a just cause to a quarrel with providence, yet custom has so entailed some ways of expence upon some stations in the world, that since a man can scarce live without them, and yet without disgrace, there are but few who are so great Stoicks, or such mortified Christians, as not to think, that what is more than enough for one, may be less than enough for another, and as to not estimate their having or wanting a competency, not only by the exigencies of nature, but by those of a man's particular quality, or station. But (subjoins *Eusebius*) he, that has, in this liberal sense, a sufficiency of outward goods, is, methinks, but ill advised, as well as unthankful, if he repine at his portion, because it is inferior to those of the famously rich: For though an unwieldy affluence may afford some empty pleasure to the imagination, (for to the body it scarce affords any at all) yet that small pleasure is far from being able to countervail the imbittering cares, that attend an overgrown

overgrown fortune; for whatever the unexperienced may imagine, the frequent and sad complaints of the rich themselves sufficiently manifest, that it is but an uneasy condition, that makes our cares necessary for things, that are merely superfluous; and that men, whose possessions are so much spread and displayed, are but thereby exposed the fairer and wider marks, that may be hit in many places by misfortune. Nor will carelessness secure them, since a provident concern of a man's estate, though it be great, being by the generality of men looked upon as a duty, and a part of prudence, he cannot suffer himself to be wronged or cheated of that, without losing, with his right, his reputation.

For my part, (says *Lindamor*) I do the more wonder to see men so greedy of lading themselves, as the Scripture speaks, with thick clay, that they hoard up their treasures from those uses, which alone make riches worthy the name of goods, and live by a temper quite contrary to that of saint *Paul*, *As having all things, and possessing nothing*. When I consider the things they pretend to by this as mean as unchristian appetite; the two chief of these are wont to be, the keeping of a great house, and the leaving their children great matches. As to the former, though others are too much advantaged by it not to extol it, and though it be sometimes indeed in some cases a decent, and almost necessary, piece of greatness; yet it is in my opinion one of the most unhappy attendants that retain to it; for the laws of hospitality, and much more those of custom, turn him, that keeps a great table, into an honourable host, subject him to comply with the various and oftentimes unreasonable humours of a succession of guests, that he cares not for at all, and that care as little for him; they bring him in a world of acquaintance, to whom he must own himself obliged, because they come to eat his meat, and must really requite them by giving them the pretiouslest thing he has to part with, his time: and a full table, together with the liberties that custom allows at it, if not exacts there, tempt him both to indulgence to his appetite, prejudicial to his health, and if they do not prevail with him to speak, do often at least dispose him to hear and to connive at, such free discourses, as are prejudicial to his interests. So that there is more than one account, upon which a great entertainer may be involved in *David's* curse against his mortal enemy, of having his table become a snare.

AND for the design (continues *Lindamor*) of laying up vast estates for a man's children; if they be sons, he thereby but increases their temptation to wish the father dead, and provides incentives to their vice, and fuel for their excesses, when he is so. And if they be daughters, not to repeat the newly-mentioned inconveniencies; how many unhappy young women have we seen, who, upon the score of the vast portions left them by their parents, have been betrayed, and sold by their guardians, or by those relations, that should have been, as they were called, their friends? And how often have we also seen, that an unwieldy fortune has been so far from purchasing the heir to it a good husband, that it has procured her a bad one, by making her think her self obliged and qualified to match with some high title, and procuring her to be haunted by some, whose vices perhaps alone have reduced him to sell himself to redeem his fortune, and to make an address which aims but at the portion, not the person? And accordingly, when he has got the one, he flights the other, and despises her for the want of that high extraction she prized in him, and perchance hates her too, for confining him from some former and more than pretended passion.

I PERCEIVE then, *Lindamor*, (says *Eusebius*) that you are, as well as I, disposed to think him not a meer fool, that prayed God to give him neither poverty, nor riches,
but

PROV. XXX.
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but to supply him with things suitable to his condition : (that seeming to be the meaning of the Hebrew phrase) a pinching poverty, and a luxuriant fortune (though different extremes) being liable to almost equal inconveniences, and a competency affording us enough to engage us to thankfulness, without administering such temptations to sensuality and pride.

DISCOURSE XX.

On seeing boys swim with bladders.

THE sun was yet so near the meridian, that if the attention *Eusebius* discourses excited, had not diverted us from minding the heat of the weather, we should have found it troublesome ; and in effect, soon after we had left shining to the conferences I have been repeating, we begun to feel a heat, uneasy enough to oblige us to retire from it ; but taking several ways, as chance or inclination directed us, to shun the same inconvenience, it was my fortune to hold the same course with *Lindamor*, and both of us, by following no guide, but the design of shunning all beaten paths, and unsheltered grounds, that being the likeliest way to reach our double end of coolness and privacy ; after we had a while walked somewhat near the river-side, we were at length brought to a shady place, which we should have found, as well as we wished it, a solitude, if others had not concurred with us in the same hopes : for the expectation of privacy had brought thither divers, whom the sun's scorching heat invited to that cool and retired part of the river, where they hoped to shun all other eyes, as well as that of heaven ; among those swimmers we observed some novices, who to secure their first attempts, had bladders tied under their arms, to keep them from sinking any lower. This sight (says *Lindamor*, after he had a while mused upon it) hath circumstances in it, that, methinks, are applicable enough to the education of many of the young ladies of these times ; of whose faults, the excellent *Celia*, and all the others, that you and I can think worth our concern, are free enough to let me entertain you without rudeness of them ; the commonness of these blemishes, ennobling those few, that are exempted from them. You cannot then (continues *Lindamor*) but have observed with me, that many of those young ladies, whose parents, out of a mistaken zeal, condemn that, which at the court was wont to be called good breeding, and principles of honour, as things below a Christian, and insufficient to bring their possessors to heaven, are so unluckily bred, and so ill-humoured, as well as fashioned, that an almost equally unhappy education is requisite to make their company tolerable. Civility, which is almost as essential to a compleat lady, as her sex, they are perfect strangers to, or rude despisers of it ; and not only their minds are not imbued with those principles of friendship, generosity, and honour, which make some of their sex so lovely, and so illustrious in story, and of which more ladies would be capable, if more were taught them ; but these are utterly uninstructed in the laws of what the French call *Bienſeance*, and are altogether unpractised in that civility and suppleness of humour, which is requisite to endear conversation, and is so proper to the softer sex. I must confess, (pursues *Lindamor*) that I never have been more puzzled how to behave my self than in their company : the serious sort of discourse (even such as is to be found in our fresher and more polished romances) they are utterly incapable of ; and in the trifling and pitiful prattle, that alone is not above them, they are so unfociable, so indiscreet, and oftentimes so bold, that in spite of the respect, such as *Celia* gives me for her sex, I find in their conversations as much exercise for my patience as my chastity ; and being tempted to put off the respect that belongs to ladies, as they do their modesty, I find

it more difficult to retain my civility than my liberty. The bladders (resumes *Lindamor*) which young swimmers use, are, it is confessed, but light and empty things, that are easily made useless; nay, though they help beginners, they are clogs to skilful swimmers; and yet these trifles are they, that hinder novices from sinking into the mud. Thus honour, though it be an airy unsolid thing, nay, though it oftentimes proves a hinderance to great proficients in Christianity, yet to persons, that have not yet attained to higher principles, it is an excellent support, and hinders them from sinking into many meannesses and miscarriages, into which those especially of the fairer sex, that want a due sense of honour, are too apt to be precipitated: you know what lord told his accused lady, that he knew she was too proud to be a whore. And certainly, though principles of gallantry include not all virtues, yet they avert those they sway from grosser vices: and though to be well bred be not to be a saint, but incomparably inferiour to it, yet to be both, is more desirable than to be the latter only: and they are very unwise, who, before they are sure their children will admit the higher and more perfect principles of religion, neglect to give them that education, that may render moral accomplishments acceptable to them, and them to well bred company, lest by proving indisposed to spiritual graces, their not having been taught the moral ornaments of the mind leave them destitute of all good qualities.

THE TRANSITION.

Containing a DISCOURSE upon the sport's being interrupted by rainy weather.

NOTWITHSTANDING the serenity and promisingness of the morning we came out in, we have already upon the water had one proof of the unsettledness of the weather, and now upon the land we meet with another: for, by that time *Lindamor* was come somewhat near the end of this discourse, he was obliged to hasten to it by the approach of a cloud, whose largeness and blackness threatned us with an imminent shower; nor did it give us a false alarm, for by that time we could recover the next shelter, the shower we fled from began to fall violently enough upon the trees, we were retired to. And this unwelcome accident reducing us all to look about us, we quickly saw, to our grief, that not only the rain but the clouds were increased, and the sky being almost every where over-cast, left us no way to escape the inconveniencies it threatned us with, but the making with what haste we could towards the place, over which we perceived smoke enough, to conclude there was some village beneath it; and finding at our arrival thither as good an inn, as we could reasonably expect in such a place, after we had a while dried our selves by the fire, *Eugenius* (to whom exercise and the time of the day had given a good stomach) moved the company, that in spite of the meanness of the house, we might rest our selves there, till we had drest the fish we had taken, to make up the best dinner the place would afford. This motion I did not alone readily assent to, but seconded it, by representing, that probably by that time we had dined, we should either recover some fair weather, or lose the hopes of regaining it for that day. To which I added other considerations, to persuade the company; though, that indeed, which prevailed with me, was, the expectation of having an opportunity, while dinner was providing, to retire, as I soon after did, into another room, and set down in short hand what I have hitherto been relating, lest either delay should make the particulars vanish out of my memory, or they should be confounded there by the accession of such new reflections, as, in case a fair afternoon should invite us to return to the river, *Eusebius* would probably meet with occasions of presenting us. But before I could handsomely sink
 away,

away, I happened to be entertained a while with some things of the like nature with those I was about to set down: for this unwelcome change, after so glorious and hopeful a morning, did naturally suggest to all of us, some thoughts of the mutability and fickleness of prosperity, how easily, as well as quickly, we may be deprived of that we cannot easily part with. But whilst the rest of us were entertaining themselves with these thoughts, *Eugenius*, who was more concerned than any other of us, for the sport he came for, having a good while looked with melancholy eyes upon this change, began to repine and murmur at the interruption, which the persisting rain continued to give him in it. Whereupon *Lindamor* took occasion to say, For my part, if I could dissipate these clouds with a wish, I should scruple at the ridding my self of them, even at so easy a rate: for I see, that the gaping clefts of the parched ground do, as it were with so many mouths, proclaim its need of the rain you repine at. And I always (continues he) am ready to join with the husbandman in his wishings, as well for rainy as for fair weather, and am so much a commonwealth's man, that I had rather at any time not escape a shower, than let him want it.

You are I confess, (says *Eugenius*) now I think a little better on it, in the right, and have more reason to be discontented at my impatience, than I at the weather: for we should, even in these lesser occasions, as well as on greater, exercise self-denial, and prefer a publick good to our private conveniences: and indeed it were far better, that I should miss some fishes, than thousands of families should miss of bread.

EUSEBIUS, that had hitherto listened to what was said, being unwilling, that his friend's ingenuity should make him any longer accuse himself, told him, (to divert the discourse) This accident, *Eugenius*, was suggesting to me a thought, wherewith I shall not scruple to acquaint you, and the company. For (continues he) as pleasant, and as much desired, as fair weather is wont to be, and as much as we use to be discontented at a lowering and dropping sky, yet the one is no less necessary nor useful in its season, than the other. For too uninterrupted a course of heat, and sun-shine, would make the season fruitful in nothing, but in caterpillars, (or such kind of vermin) and in diseases, and is far more proper to fill graves, than barns: whereas seasonable vicissitudes of clouds, and cloudy weather, make both the ground fruitful, and the season healthful. Thus in our outward condition, too long and constant a prosperity is wont to make the soul barren of all, but such wantonnesses, as it is ill to be fruitful of, and the interposition of seasonable afflictions is as necessary, and advantageous, as it can be unwelcome. But (pursues *Eusebius*) the consideration, that chiefly entertained me, was this, that as here, to make the earth fruitful, the face of heaven must be now and then obscured, and overcast, we must be deprived of the welcome pleasure of the sun to receive the fertilizing benefit of the rain; so such is our condition here below, that our perverseness makes it necessary, that God should oftentimes appear to frown upon us, to make us fruitful in those works, to which he is pleased to vouchsafe his smiles. But, oh! (concludes *Eusebius*, lifting up his eyes and hands towards heaven) how happy shall we be in that glorious and everlasting day, when our condition shall be as blessed in not requiring vicissitudes as in not being subject to them! When the sun-shine alone shall perform all that is wont to be done here both by it, and by the rain; and the soul, like *Egypt*, being fruitful without the assistance of the clouds, we shall not need to have our joys eclipsed, to have our graces kept from being so, or to make our light shine the brighter: but each blessed soul shall be emblemed by that vision in the revelations, where *St. John* saw an angel standing in the sun; we shall not then need to have our

love

love weaned from inferiour or undue objects, by any experience of their imperfections; since the clear discovery, that God will vouchsafe us of his own excellencies, will abundantly suffice to confine our affections to them; and since the works, wherein we are to be fruitful in heaven, will be but to admire and thank him, that is infinite in beauty and in goodness, the perfecter sight and fruition we shall have of his astonishing as well as ravishing attributes, will but proportionably increase our wonder, and our praises, and will naturally make us as grateful for such a state as happy in it.

OCCASIONAL REFLECTIONS.

SECTION V.

REFLECTION I.

Upon the sight of N. N. making of syrup of violets.

ONE, that did not know the medicinal virtues of violets, and were not acquainted with the charitable intentions of the skilful person, that is making a syrup of them, would think him a very great friend to Epicurism: for his employment seems wholly designed to gratify the senses. The things he deals with are flowers and sugar, and of them he is solicitous to make a composition, that may delight more than one or two senses; for in one syrup he endeavours to please the eye, by the loveliness of the colour; the nose, by the perfume of the scent; the taste, by as much sweetness as sugar can impart. But he that knowing, that violets, though they please the palate, can purge the body, and notwithstanding their good smell, can expel bad humours, knows also, that the preparer of these fragrant plants, in making their juice into a syrup, is careful to make it acceptable, that its pleasantness might recommend it, and invite even those to prove its virtues, who had rather continue sick, than make trial of a disgusting remedy; will not blame his curiosity, but commend his prudent charity; since he doubly obliges a patient, that not only presents him remedies, but presents him allurements to make use of them.

IF I see a person, that is learned and eloquent, as well as pious, busied about giving his sermons, or other devout compositions, the ornaments and advantages, which learning or wit do naturally confer upon those productions of the tongue, or pen, wherein they are plentifully and judiciously employed; I will not be forward to condemn him of a mis-expenditure of his time or talents; whether they be laid out upon speculative notions in theology, or upon critical inquiries into obsolete rites, or disputable etymologies; or upon philosophical disquisitions or experiments; or upon the florid embellishments of language; or (in short) upon some such other thing, as seems extrinsic to the doctrine, that is according to godliness, and seems not to have any direct tendency to the promoting of piety and the kindling of devotion. For I consider, that as God hath made man subject to several wants, and hath both given him several allowable appetites, and endowed him with various faculties and abilities to gratify them; so a man's pen may be very warrantably and usefully employed, though it be not directly so, to teach a theological truth, or incite the reader's zeal.

AND, besides what I have been alledging, there is a further, and more principal consideration, which belongs to this matter. For even wise men may prosecute the same design, without doing it all of them the same way; and the several means and methods they employ, notwithstanding a great difference in other particulars, may agree in this, that the respective chusers of them had each of them a good aim, and proceeded in a rational way. Though therefore I see a man of good parts, studious of learning, or of practising, the precepts of eloquence, and spend much time in reading florid composures, or in making such; I dare not be forward to censure him for an effeminate or useless writer. For there are so many things pious or laudable, and so many ways, whereby some or other of them may either be directly promoted, or indirectly served, by removing objections, or other impediments, that it is not easy to be sure, that a rational man cannot have as well a rational as a well-meant design to instruct, if not reform, in those very composures, that seem fitted only to delight. There being a nicer sort of readers, which need instruction (and to whom it is therefore a charity to give it) who are so far from being likely to be prevailed on by discourses not tricked up with flowers of rhetoric, that they would scarce be drawn so much as to cast their eyes on them.

A WHILE before *Ester* made that generous attempt, wherein, to rescue the people of God, she hazarded a throne, to which above an hundred other peoples paid homage, and ventured at once the greatest crown and the fairest head in the world; one, that had seen only what she was doing, without knowing why she did it, would perchance have thought her employed, more like a disciple of *Epicurus* than of *Moses*, whose people and her own was then in a forlorn and gasping condition. For the Scripture telling us, that *she put on her royal apparel*, and the tenour of the story intimating with what aim she did it, we may well suppose, that she was not sparing in jewels and other of the richest ornaments, on an occasion, where her quality exacted, that she should appear with a magnificence befitting the greatest princefs in the world; and that she was very curious in a dress, that was to heighten her beauty, when by that, with the giver's assistance, she was upon her knees, to dazzle the world's greatest monarch on his throne, and make him pay homage to her charms, to whom above an hundred nations had presented their fairest productions, (the brightest nymphs of the East). And those, that have read any thing of the Asiatick luxury, will easily believe our pious queen to have been also very solicitous about the choice and ordering of her sweetmeats, when she was to treat an Asian monarch, who had treated the whole people of the chief city of the world for many days together, and as many princes, as made up the noblest part of mankind, for above twenty times as long: and yet this magnificent queen, that seemed busied about none but sensual employments, had so commendable a design both in her ornaments, and in her banquets, that so meritorious an employment of her greatness shewed her to be worthy of it; and, as it appeared in the event, that her banquets did co-operate with her fasts, and her royal robes with *Mordecai's* sack-cloth and ashes, to that happy rescue of her nation, for which, after so many ages, it doth to this day yearly celebrate her memory: so whilst she seemed busied to gratify others sensuality and her own pride, her disposition of mind was so worthy the success, that crowned her attempt, that at the same time she was providing all that pomp and those delicacies, she was also providing to give them, and sacrifice them, for the interest of God's church, and her people; generously venturing for the service of heaven a height of prosperity, for whose loss nothing but heaven itself could make her amends.

REFLECTION II.

Upon the sight of a paper-kite in a windy day.

EUGENIUS, LINDAMOR.

EUG. IF the air were calm and quiet, this kite would lie unregarded even by those very youths, that now look at nothing else. But the wind, that blows away straws and feathers, and throws down leaves, does even by its being contrary, help to raise this paper-engine to that admired height, which makes it be gazed at by many others, than boys, and not only attract our eyes, but sometimes soar out of their reach. Thus, if a great person, for courage, or parts, or both, have the ill fate to live in quiet, and peaceful times, he may long enough languish unregarded in an age that needs him not. But if the times grow troublesome and dangerous, his generous spirit will not only surmount the difficulties, that are wont to attend them, but be raised by them, and turn them into steps to glory and preferment.

LIND. Methinks, *Eugenius*, these kites may afford us no less fit a resemblance of the fate of some errors about religion, especially if they chance to be maintained by men, that are resolute, and viceless. For there are some of these conceits so fond, and groundless, that they could not long subsist of themselves, and would soon cease to tempt a solemn opposition, if they did not too soon meet with it. And as you were observing to another purpose, that these artificial kites, which men take no notice of in calm weather, are both elevated and kept aloft by the blasts of contrary winds; so these erroneous opinions I speak of, would, if they were let alone, grow quickly unregarded, whereas needless or ill-managed persecutions of doctrine, not prejudicial to government, (for it is only such, that I mean) bring them into every body's eye, and give them a repute, that nothing else would have procured them, and make them be looked upon as things of a sublime and celestial nature, that lead to that heaven, they seem to aspire to. To thrive by persecution, though it be a great advantage, yet it is not the incommunicable prerogative of divine truths; and though it be certain that they get most by it, yet even errors do often gain by it too, there being certain advantages, that accrue to opinions, by being persecuted, without distinguishing, whether they be true, or false. For men, that are persecuted for their religion, are generally careful to instruct themselves thoroughly in it, and furnish themselves with arguments to defend it. The frowns of the magistrate, and the watchful eyes of their adversaries, are strong dissuatives to them from doing any thing, that may arm his hand, or provoke other's tongues against their sect, to which they know their personal faults will be imputed. And above all this, their sufferings intitle them to popular commiseration, which is a thing, that distress does so much invite, that even condemned malefactors seldom want a share in it. And to some of these men persecution is the more favourable, because it puts them upon fighting with the weapons they can best handle. For some are far better at suffering, than at disputing, and can more easily endure a prison, than answer a syllogism. And as this constancy is often their best argument, so is it an argument, that the generality of men best understand, and consequently is likely to be most wrought on by; so that the more harsh than effectual way, wherein they are dealt with, gives them the opportunity to display a resoluteness, that makes most men think them well meaning, and in earnest, and their own party cry them up for martyrs, or at least confessors; which, in case that (as it happens

happens in most states) scandalous sins be left unpunished at the same time, that harmless errors are so severely dealt with, gives them the fairer opportunity to insinuate into the minds of the people, that their persecutors had rather see men vicious, than inquisitive. And, generally speaking, any personal sufferings, that a well-meaning man undergoes for what he judges his conscience, is but such a kind of burden to his mind, as feathers are to an eagle, or a falcon, which, though in themselves considered they have a weight, yet instead of clogging him, they not only help him to support himself, but enable him to soar towards heaven, and reach a height, that makes him praised or wondered at.

REFLECTION III.

Killing a crow (out of a window) in a hog's trough, and immediately tracing the ensuing reflection with a pen made of one of his quills.

Gen. xv. 16.

Luke xvi.
28.
2 Sam. ii.
26.

Num. xxv.

Num. xi.
33.

Judges xvi.

LONG and patiently did I wait for this unlucky crow, wallowing in the sluttish trough, (whose sides kept him a great while out of the reach of my gun) and gorging himself with no less greediness, than the very swinish proprietaries of the feast, till at length having guzzled and croaked enough, when by hovering over his beloved dainties, he had raised himself high enough, to prompt me to fire at him, my no less unexpected, than fatal shot, in a moment struck him down, and turning the scene of his delight into that of his pangs, made him abruptly alter his note, and change his triumphant chant for a dismal and tragick noise. This method is not unusual to divine justice towards brawny and incorrigible sinners, whose souls no less black, than this inauspicious bird's feathers, do wear already the livery of the prince of darkness, and with greediness do the works of it, whose delights are furnished (as the feasts of crows are by carion) by their own filthy lusts, or other people's faults, and who by the oaths and curses, wherewith they offend Christian ears whilst they live, and by the ill odour they leave behind them when they are dead, do but too much justify my resembling them to these hateful creatures. Such sensual and obdurate Epicures, I say, God oft times suffers to run on their long career, in paths of their own chusing, without checking them in the fruition of those joys, which are to be their only portion, till at length *their iniquity filling up the determinate measure*, he cuts them off, in the height of their enjoyments, and employing oft-times their own sins for their executioners, or at least instruments of their destruction, precipitates them headlong from the pinnacle of their delights, into the bottomless pit, which one of their predecessors (the rich man in the parable) called, as he sadly found it, the *place of torment*, where the luscious sweets of sin are so dearly reckoned for, and afford so much *bitterness in the latter end*, that their sense sadly convinces them, of (what their sensuality kept them from believing) the folly of gaining any thing at the rate of losing their own souls. Thus the Israelitish prince found a Nemesis bold enough to violate the sanctuary, even of his mistress's arms, and (regardless of its charms) enter that lovely circle, their kindness closed him in, to snatch him thence, and extinguish the lustful flames, that lighted him thither, with the cold blasts of death. Thus the mutinous loathers of manna, and lusters after flesh, had their wish severely granted, for they had indeed quails served in by fields-full, but attended with so sudden and sharp a reckoning, that *whilst the flesh was yet between their teeth, ere it was chewed*, death hindered them to swallow it, choaked them with it, and devoured them as greedily, as they did those birds. Thus the insolent Philistines found themselves ill protected by their vainly celebrated God, and his (much stronger) temple, though in the latter there were thousands of them, without any other enemy, than one, they had

had sent for to be a friend to their mirth. For in the very midst of all the triumphs of a solemn festival (which had more properly been kept to *Dalilah*) whilst they were insulting over captive *Sampson's* blindness, they could not see their own approaching destiny, though it were then so near, that the next fit of laughter had not time to pass to their mouths, ere an unexpected vengeance (the provoked Deity lending an omnipotent arm to *Sampson's* hand) confounded in one ruin, the idol with the worshippers, and suddenly turned the whole temple into an altar, with which the priests themselves fell surprized sacrifices to that tragical solemnity. And thus (to hasten from so sad a theme) the revelling *Belfazzar*, in the midst of his magnificent and royal feast, saw an intruding hand, which by its manner of appearing, as well as by what it wrote, was able to mar the supper, without impairing the dainties. And that monarch, whom even a siege could not reduce below a condition of feasting, though he were carousing in the consecrated cups, had such a brimmer of trembling put into his hand, as both presaged, and perchance, began the destiny approaching him under the ensigns of the noble *Cyrus*, whose conquering sword, guided by providence, and made the sword of justice, did that very same night let out his wine, and blood, and life together.

Upon the same subject.

IT is hard on such an occasion to avoid making some reflection upon the mutability of worldly conditions! How little did this crow imagine, a quarter of an hour since, that in so short a time, his body should be as senseless, and as stinking carrion, as that he was wont to feed it with; that his feathers should wear so unlucky a kind of mourning for his destruction, and that I should write his epitaph with one of his own quills! Sure, since a few minutes can turn the healthiest bodies into breathless carcases, and put those very things into the hands of our enemies, which were they, that we principally relied on for our safety, it were little less than madness, to repose a distrustless trust in these transitory possessions, or treacherous advantages, which we enjoy but by so fickle a tenure. No; we must never venture to wander far from God, upon the presumption, that death is far enough from us; but rather in the very height of our jollities, we should endeavour to remember, that they, who feast themselves to-day, may themselves prove feasts for the worms to-morrow.

REFLECTION IV.

Upon a glow-worm, that he kept included in a crystal phial.

At Lees,

IF this unhappy worm had been as despicable as the other reptiles, that crept up and down the hedge, whence I took him, he might, as well as they, have been left there still; and his own obscurity, as well as that of the night, had preserved him from the confinement he now suffers. And if, as he sometimes for a pretty while withdrew that luminous liquor, that is as it were the candle to this dark lanthorn, he had continued to forbear the disclosing of it, he might have deluded my search, and escaped his present confinement.

RARE qualities may sometimes be prerogatives, without being advantages. And though a needless ostentation of one's excellencies may be more glorious, yet a modest concealment of them is usually more safe: and an unseasonable disclosure of flashes of wit, may sometimes do a man no other service, than to direct his adversaries, how they may do him a mischief.

AND as though this worm be lodged in a crystalline prison, through which it has the honour to be gazed at by many eyes, and, among them, by some, that are said to shine far more in the day than this creature does in the night; yet no doubt,
if

if he could express a sense of the condition he is in, he would bewail it, and think himself unhappy in an excellency, which procures him at once admiration and captivity, by the former of which he does but give others a pleasure, while in the latter he himselfresents a misery.

THIS oftentimes is the fate of a great wit, whom the advantage he has of ordinary men in knowledge, the light of the mind exposes to so many effects of other men's importunate curiosity, as to turn his prerogative into a trouble: the light, that ennobles him, tempts inquisitive men to keep him, as upon the score we do this glow-worm, from sleeping: and his conspicuousness is not more a friend to his fame, than an enemy to his quiet; for men allow such much praise, but little rest. They attract the eyes of others, but are not suffered to shut their own; and find, that by a very disadvantageous bargain, they are reduced for that imaginary good, called fame, to pay that real blessing, liberty.

AND, as though this luminous creature be himself imprisoned in so close a body as glass, yet the light, that ennobles him, is not thereby restrained from diffusing it self: so there are certain truths, that have in them so much of native light or evidence, that by the personal distresses of the proposer, it cannot be hidden, or restrained; but in spite of prisons, it shines freely, and procures the teachers of it admiration, even when it cannot procure them liberty.

REFLECTION V.

Upon a court's being put into mourning.

PART I*.

GENORIO, EUSEBIUS, LINDAMOR.

GENOR. **M**ETHINKS, you look, *Eusebius*, as if the change, that blacks have made in this place, since I last saw you here, tempts you to question, whether or no this be the court.

LIND. Yet, I fear, *Eusebius* will scarce doubt, that you, and these other gentlemen are courtiers, whilst he sees, how much you dissemble in personating sadness: for though your clothes look mournful, your faces do not, and you talk to one another as unconcernedly, as when you wore lighter colours; and your grief is so slight, that it has not an influence so much as upon your looks, and words, which yet are things, that courtiers are said to be able to disguise without an over-difficult constraint.

GENOR. But, I hope, *Lindamor*, I need not labour to persuade such as you, that, when we seem to mourn, without doing it, we may be thought guilty of dissimulation, without being so: for what duty is there, that you and I should be really troubled for the death of a prince, whose subjects we were not, who never obliged us, and who perhaps did only keep the power of doing good, which himself never used, from a successor, that had the will to employ it? But you will demand, why then we put on black; to which the answer is easy, that custom having established that ceremony in the courts of princes, in amity with each other, the omission would be looked upon as an affront, and be a provocation. And therefore, the blacks we wear, are not meant to express a grief for the dead, but a respect to their living relations: and thus, this as heartless as solemn shew of mourning is not put on by hypocrisy,

* For there was a second part of this reflection, but when it was to be sent to the press it could not be found, nor would the press's haste, and the author's occasions, allow him either to stay till it were found, or write a new one.

but by prudence, or civility. And in this case, I would appeal to *Eusebius* himself, but that I perceive some object or other has, ever since we began to talk, engrossed his attention, as well as sealed up his lips.

LIND. I have taken notice of it, as well as you, *Genorio*, and I confess, I would give much to learn his thoughts.

EUSEB. It is odds then, *Lindamor*, that you would over-purchase so worthless a knowledge: and to satisfy your curiosity at an easier rate, I will tell you, that I was observing, how a gentleman, who, it seems, does not much frequent the court, chancing to come in a coloured suit, that, but last week, would have been thought a fine one, was stared at by all in the room except your selves, whose faces chanced to be turned from him, like a man of another country, (not to say of another world) which the poor gentleman at length perceiving, he soon grew so sensible of it, that in spite of the richness and newness of his clothes, with many blushes he slunk out of the court, to which he found men's gazing at him concluded him to be a stranger.

LIND. But this, *Eusebius*, is only to tell us, what you observed, not what reflections you made upon it; and you know, that which I was inquisitive after, was your thoughts.

EUSEB. I will add then, *Lindamor*, since you will have it so, that I was considering, that there has been no law made by the state to forbid any, much less strangers, to appear in this court in coloured clothes: and those, which the gentleman I was speaking of, had on, were such, both for fineness, and fashionableness, as would very well become a greater court, if it were not in mourning. But, now the prince, and those, that have the honour to belong to him, or to frequent this place, have put themselves into blacks, to appear in another, though in a finer habit, is, to betray one's not belonging to the court, nor using to come to it; and among so many, that think they have a right to give laws in point of clothes, a laced, or an imbroidered suit, though last week in request, would, now they have laid them by, make a man look not so much like a courtier, as a player. And this reflection invited me to consider further, what a strange influence fashions have on mankind, and what an happy change might be easily made in the world, if they, who have it in their power to introduce customs, would make it their endeavour to introduce good ones.

LIND. I am so much of your mind, *Eusebius*, that I confess, I envy not princes so much for the splendour and the pleasures that they live in, nor for the authority of raising armies, nor, perchance, for the happiness of making them victorious, as for the power of imposing and reforming of fashions. And I think it a less improveable prerogative, to be able to coin any metal into money, or call it in at pleasure, than by the stamp of their authority to introduce good customs, and make them current.

GENOR. But, do not princes enough, when they take care to make good laws, and see them well executed?

LIND. I will not dispute, whether by that, they do all they ought, but sure I am, they do not all they may: for human laws being made for the civil peace of human societies, they are wont to be framed not for the making men virtuous, but the restraining them from being mischievous; they consist far more of prohibitions than commands, and even their prohibitions reach but to a little part of what is ill; the business of laws being to provide, not against all evils, but those grosser ones, that are prejudicial to civil societies: so that there are a thousand rules of reason, or Christianity, which states have not thought fit to turn into laws. For pride, envy, covetousness, gluttony, intemperance, effeminateness, oaths, idleness, and I know not

how

how many other sins, contrary to the laws of nature, and of Christ, are so little provided against by human sanctions, that one may be a bad Christian, and a bad man, without being a bad citizen; there being nothing more easy, nor, I fear, more usual, than for multitudes to pass uncited before man's tribunal, to receive their condemnation at God's. But though a prince can scarce, as a legislator, prevent, or suppress such sins, yet, as a pattern, he may do much towards it: for by his example, his opinions, his encouragements, and his frowns, he may reform an hundred particular things, which the laws do not (and perhaps cannot) reach. His declared esteem of such and such practices, joined with his particular actions suited to it, and his profest dislike of those sinful or dishonourable courses, he finds the ripest, backed with a steady and resolute discountenance of those, that do not decline them, will, in a short time, bring those, that are about him, to conform their actions and behaviour to what men are satisfied, he desires, or likes. And those, whom their nearness to him, or their employments, make the conspicuous and exemplary persons, being thus modeled, their relations and dependants will quickly be so too; and then that which is in request at court, being upon that very account looked upon as the fashion, it will by degrees be imitated by all those, on whom the court has influence; since, as we just now saw in the instance of *Eusebius's* gaudy gentleman, men will be ashamed to be unlike those, whose customs and deportments pass for the standards, by which those of other men are to be measured.

REFLECTION VI.

Upon bearing of a lute first tuned, and then excellently played on.

THE jarring strings made so unpleasant a noise, whilst the instrument was tuning, that I wonder not at the story, that goes of a Grand Signior, who being invited by a Christian ambassador to hear some of our musick, commanded the fiddlers to be thrust out of his seraglio, upon a mis-apprehension, that they were playing, when they were but tuning. But this rare artist had no sooner put an end to the short exercise he gave our patience, than he put us to the exercise of another virtue; for his nimble and skilful fingers make one of the innocentest pleasures of the senses to be one of the greatest, and this charming melody (for which *Orpheus* or *Orion* themselves might envy him) does not so properly delight as ravish us, and render it difficult to moderate the transports of our passions, but impossible to restrain the praises, that express our satisfaction: so that if this musician had been discouraged by the unpleasant sounds, that were not to be avoided, whilst he was putting his lute in tune, from proceeding in his work, he had been very much wanting to himself, and to save a little pains, had lost a great deal of pleasure and applause.

Thus, when the faculties and passions of the mind, either through a native unruliness, or the remissness of reason and conscience, are discomposed, he, that attempts to bring them into order, must expect to meet at first but an uneasy task, and find the beginning of a reformation more troublesome, for the time, than the past disorders were: but he is very little his own friend, if he suffers these short-lived difficulties to make him leave his endeavours unprosecuted; for when once they have reduced the untuned faculties and affections of the soul to that pass, which reason and religion would have them brought to, the tuned or composed mind affords a satisfaction, whose greatness does even at present abundantly recompence the trouble of procuring it, and which is yet but a prelude to that more ravishing melody, wherein

wherein the soul (already harmonious within itself) shall hereafter bear a part, where the harps of the saints accompany the glad voices, that sing the song of the lamb, and the allelujahs of the rest of the celestial choir.

REFLECTION VII.

Upon being presented with a rare nosegay by a gardener.

LINDAMOR, EUSEBIUS.

LIND. **H**ERE is indeed a present, for which I must still think myself this fellow's debtor, though he thinks I have overpaid him. It is pity these rarities were not more suitably address'd, and worn by some of nature's other master-pieces, with whom they might exchange a graceful lustre, and have the ornament they confer reflected back upon them. But one, that had never been a lover, would perhaps say, that that wish were more civil to the flowers, than the ladies, of whom there are few, which these soft polished skins, and orient tinctures, would not easilier make foils, than prove such to them: for (not to name the rest) this lovely fragrant rose here wears a blush, that needs not do so, at any colour the spring itself can, amongst all her charming rarities, shew. Yes, here are flowers above the flattery of those of rhetorick; and besides, two or three unmingled liveries, whose single colours are bright, and taking enough to exclude the wish of a diversity, here is a variety of flowers, whose dyes are so dexterously blended, and fitly chequered, that every single flower is a variety. I envy not *Arabia's* odours, whilst that of this fresh blusher charms my sense, and find my nose and eyes so ravishingly entertained here, that the bee extracts less sweetness out of flowers; which were they but less frail, I fear would make me more so than yet I am. Surely this gardener leads a happy life! He inherits nothing of *Adam*, but that primitive profession, that employ'd and recompens'd his innocence, and such a gay and privileged plot of his *Eden*, as seems exempted from the general curse, and instead of the thorns and thistles, that are the unthankful earth's wonted productions, brings him forth lillies and tulips, and gratefully crowns his culture (for toil I cannot think it) with chaplets of flowers.

EUSEB. I perceive, (*Lindamor*) that you judge of the delightfulness of this man's calling, only by these lovely and fragrant productions of it. And you see these curious flowers in their prime, without seeing by what practices, and degrees, they have been brought from despicable seeds to this perfection and lustre. And perhaps, if you consider'd, that a gardener must be digging in the violent heats of the summer, and must be afraid of the bitter cold of the winter, and must be watchful against surprising frosts in the spring, and must not only prune, and water, and weed his ground, but must, to obtain these gaudy and odoriferous flowers, submit to deal with homely and stinking dung: if (*Lindamor*) you would take notice of these and of some other toils, and hardships, that attend a gardener's trade, you would (I doubt not) confess, that his employments, like his bushes, bring him thorns as well as roses.

AND now give me leave (*Lindamor*) to tell you, that this may be applied to the condition of some studious persons, that you and I know. For when we hear a learned or eloquent sermon, or read some book of devotion, or perhaps some occasional discourse handsomely written, we are apt to envy the preacher or the writer, for being able to say some things, that instruct or please us so much. But alas, (*Lindamor*) though we see not these productions of the brain till they are finished,

and consequently fitted to appear with their full advantages abroad ; yet to bring them to that pass, the author may perhaps undergo many a trouble, that we dream not of. For he, that has to do with difficult or weighty subjects, cannot present us a good book, or a fine discourse, with the same ease, that a rich man can present us a fine pair of gloves, or a fine collation, which may be had at an hour's warning from the next milliner's or confectioner's. For to be able to write one good book on some subjects, a man must have been at the trouble to read an hundred : to grow capable to give a better rendering of a Greek text, he must, perchance, have perused *Suidas*, *Stephanus*, *Hesychius*, and I know not how many lexicographers and scholiasts : to be qualified to make a translation of an Hebrew word or phrase, that shall illustrate a dark text, or clear a difficulty, or more fitly agree with his notion, or accommodation of a place in Scripture, a man must have not only, like a school-boy, learned an Hebrew grammar, and turned over *Buxtorf's*, *Schindler's*, and other dictionaries, but (which is worse) he must, in many cases, hazard his eyes and his patience in conversing with such Jewish writings, not only as *Elias* his *Tishbi*, and *Kimchi's Michlol* ; but to gain a little rabbinical learning, and find out some unobvious signification of a word or phrase, he must devour the tedious and voluminous rhapsodies, that make up the Talmud, in many of which he can scarce learn any thing, but the art of saying nothing in a multitude of words ; and in others, which are not so useless, the most he will find in I know not how many dull pages, (written with as little wit as truth) will perhaps be an account of some wild opinion, or some obsolete custom, or some superstitious rite of a generation of people, whose fancies and manners scarce any thing makes worth our inquiring after, but their having lived many ages since. And even when a man sets himself to write those smooth composures, where eloquence is conspicuous, and seems to be chiefly designed, the author seldom comes by his contentment on as easy terms as the readers come by theirs. For, not to mention, that sometimes periods, that in a well-printed book look very handsomely, and run very evenly, were not in the written copy without interlining and transcriptions ; those, that are scholars themselves, can hardly write without having an ambition, or at least a care, to approve their discourses to them that are so too. And in the judgment of such perusers, to be able to write well, one must not only have skill in the subject, but be well skilled in the way of writing, lest the matter be blemished by the manner of handling it. And although to shew one's self a master, in treating of variety of themes with a florid style, and even in those composures, that are designed chiefly to express wit and move affections, one may think, that nature may be well let alone to supply any she has been kind to, with all they need, yet even in these cases there are some toils and uneasinesses, that are scarce to be avoided ; since a discreet man, though never so rich in nature's gifts, will think himself obliged to study rhetorick, that he may be sure he does not transgress the laws of it. For though an author's natural parts may make his book abound with wit, yet without the help of art he will scarce make it free from faults. And to be well stocked with comparisons, which, when skilfully managed, make the most taking passages of fine pieces, one must sometimes survey and range through the works of nature and art, which are the chief warehouses, where variety and choice of similitudes is to be had ; and to obtain those pleasing ornaments, there is oftentimes required no less pains than to devise useful notions. As one must search the ditches among briars and weeds, not only to find medicinable herbs, but to gather primroses and violets. So that (*Lindamor*) to conclude, if we consider the trouble, that applauded composures do oftentimes cost their authors, we should be sensible we owe more, than most men think we do, to those, to whom we owe good books. But then unless

they find some recompence for their labours, in the satisfaction of promoting piety, or in the well-natured pleasure they feel themselves in pleasing others, I should scarce doubt, but that some of the writers, we think so happy, may rather deserve our esteem than our envy.

REFLECTION VIII.

Upon a child that cried for the stars.

I REMEMBER P. S. did once, upon just the like theme, discourse to the following purpose.

AMONGST those numerous eyes, that these fair lights attract in so clear a night as this, there are not perhaps any, that are more delighted with them, than this child's seem to be. And those Persians, that adored the rising sun, could not be more charmed with that glorious object, than this child is with these twinkling lights, that need his absence to become so much as visible. But his is a pleasure, that is not more great than unquiet, for it makes him querulous, and unruly; and because he cannot by his struggling, and reaching forth his little hands, get possession of these shining spangles*, that look so finely, their fires produce water in his eyes, and cries in his mouth, that are very little of kin to the musick the Platonists fancied in the spheres he looks at. Whereas, though my inclinations for astronomy make me so diligent a gazer on the stars, that in spite of my great obnoxiousness to the inclemency of the nocturnal air, I gladly spend the coldest hours of the night in contemplating them; I can yet look upon these bright ornaments of heaven it self, with a mind as calm and serene, as those very nights, that are fittest to observe them in.

I KNOW divers men, for whom nature seems to have cut out too much work, in giving them, in an unconfinedly amorous disposition of mind, strong appetites for almost all the fair objects, that present themselves to their sight; these amorous persons may be, I grant, very much delighted, when they first gaze upon a constellation of fair ladies; but the heart commonly pays dear for the pleasure of the eye, and the eager desires, that beauty creates, are in such men excited too often not to be frequently disappointed, and are wont to be accompanied with so many jealousies, and fears, and repulses, and difficulties, and dangers, and remorses, and despairs, that the unhappy lovers (if those, that love more than one, can merit that title) do rather languish than live, if you will believe either their own querulous words, or their pale and melancholy looks, which would make one think they were just entering into the grave, or had been newly digged out of it. Whereas a person, that has his affections and senses, at that command, which reason and religion require and confer, can look upon the same objects with pleased but not with dazzled eyes: he considers these bright and curious productions, as fair animated statues of nature's framing, and contenting himself to admire the workmanship, adores only the divine artificer, whose infinite amiableness is but faintly shadowed forth even by such lovely creatures. And therefore what has been said of mistresses, may be more justly applicable to all the other objects of men's too eager passions. To be short, looking upon these curiousest productions of nature, with a philosopher's and a Christian's eyes, he can cast them on those bright objects with pleasure, and yet withdraw them without trouble, and allowing beauty to contribute to his delight, without being able to create him any disquiet; though it afford him a less transporting pleasure than it

* Thus in a starry night fond children cry
For the rich spangles, that adorn the sky. Mr. W.

sometimes does the amorist, yet, all things considered, it may afford him a greater pleasure, by being more innocent, more untroubled, and more lasting; and there may be such a difference betwixt the contentment of this calm admirer of beauty, and that of a greedy and unconfined profligator of his heart to it, as there is betwixt the unquiet pleasure, that the sight of the stars gives to this child, and the rational contentment it may afford to an astronomer.

REFLECTION IX.

Upon my lady D. R. her fine closet.

LINDAMOR, EUSEBIUS.

A. D.
1651.

LIND. IS not this closet strangely fine, *Eusebius*? Here is such a variety of pretty and taking objects, that they do as well distract the eye as delight it; the abundance, the choice, and the order, do as well disclose the fair possessor's skill, as her magnificence, and shew at once, that she both has plenty, and deserves it, by knowing so well how to make use of it. Those things, that are here solitary, or single, will scarce be elsewhere matched; and all the rest are so pretty, and so excellent in their several kinds, that the number of fine things, that make up this curious collection, cannot hinder any of them from being a rarity. And in a word, the embellishments, that adorn and ennoble this delightful place, are such, that I believe the possessor of them, as welcome as she is unto the best companies, scarce ever looks upon finer things, than she can see in her closet, unless when she looks into her glass. But, methinks, *Eusebius*, you hear and view all this with a silent seriousness, which begins to make me suspect, that what I thought might be an effect of your wonder, may be so of your dislike.

EUSEB. The collection, *Lindamor*, is, I confess, very curious in its kind, and such as if the mistress of it were less handsome than she is, might give her as well cause to be jealous of these fine things, as to be proud of them, since a beauty, that were but ordinary, could not divert a spectator's eye from objects, whereof many are not so. But, *Lindamor*, I must freely tell you, that I like both the lady, and the closet, much better than the custom such sights as these are introducing among ladies of furnishing such kind of closets: I know, that youth may in certain cases, excuse some of the impertinencies it is wont to occasion; and it is not strange to me, that persons of the fairer sex should like, in all things about them, that handsomeness, for which they find themselves to be the most liked; nor would I forbid, even such of them, as are not of a very high quality, to have a retiring place so neatly adorned, as may invite them to be alone, and withdraw to it, to read, or meditate, provided these ornaments be not so costly, as to rob charity, or so gaudy, as to distract the devotion they should but accommodate. And in case circumstances should so conspire, as that youth and quality should be attended by such a plentiful fortune, as that after all, that either justice, prudence, or decency can challenge, there remains yet enough, both to relieve the poor, and purchase rarities themselves; I will not be so severe, as to condemn persons so circumstanced, nor fall out with those, that are able to reconcile sumptuousness and charity. But the number of such ladies, especially so soon after a long civil war, must needs be but small, and I fear much inferior to that of those, who will consider more what they see done before their eyes, than they will the disparity of circumstances betwixt their own condition, and that of those they emulate: and the greater appearance of ingeniousness, as well as innocence, there is in the practice I am disapproving, the more dangerous it is, and the more fit to be examined

examined and decryed. For as the old serpent has variety of wiles, so he fits them to the various tempers of the persons he assails to work upon; and when he meets with ladies virtuously disposed, since he cannot quite eradicate their inclinations to the best part of religion, charity, he will at least blast and render them fruitless; and he justly thinks, he has reached no small part of his end, if though he cannot seduce them to do ill, he can at least hinder them from doing good. And this he has of late attempted but too prosperously, by persuading us to take those for the standard and examples of our expences, that making none of the score of piety, have the more left for their vanities and their appetites; which they gratify at such high rates, that those, that think themselves bound to imitate them in those excesses, that are misnamed gallantry, shall have as little ability as the other have will, to apply any considerable part of their estates to those uses, which chiefly God granted them those estates for; and by that time, the lady her self, and the house, and the closet, are furnished with all the ornaments, that vanity and emulation call for, there is nothing left for charity to dispose of, nay, perhaps not for justice; the creditor being oftentimes turned back empty as well as the beggar, if not also made a beggar by ruinous delays. And greater fortunes, than most ladies have, may be exhausted, by gratifying such an ambition, as that of a closet, to whose costliness nothing can put limits, till discretion do; custom it self having not yet regulated a piece of vanity, which, as imposing as custom is wont to be, it has not yet dared to enjoin.

LIND. Methinks, *Eusebius*, you are somewhat forward to accuse those fair creatures, that though they should want innocence, would scarce want advocates; and you are too good a casuist to ignore, that they are wont to alledge, that the bravery you are so severe to, is no where expressly prohibited in the Scripture; and this unforbiddenness they think sufficient to evince, that the sumptuousness you so condemn, is not absolutely, and in its own nature, sinful.

EUSEB. I can readily believe, that *Lindamor* has wit and amorousness enough to make him find it more easy to defend fair ladies, than to defend himself against them; and I know, it is said, that these sumptuous closets, and other vanities, are not simply unlawful in their own nature: but I know too, that divers things, not in their own nature unlawful, may be made so by circumstances; and if so, then I fear, that that can be no other than ill, which makes a man needlessly disable himself to do good. The Apostle, that discountenanced women's wearing of gold, or precious things upon their bodies, would sure have opposed their having more sumptuous ornaments upon their walls: these cannot pray for us, but the poor and distressed, they keep us from relieving, may either successfully pray to God for us, or cry to him against us. The Scripture, that represents *Dives* in hell, without saying, that he oppressed or defrauded any, gives no other account of his doom, than that living at a high rate, and going richly dressed, he neglected to relieve the starving poor. A few such closets as this lady's might be easily enlarged, and contrived into an hospital: a small part of these superfluities would relieve the necessities of many families, and a liberal heart might purchase heaven at an easier rate, than the furniture of this closet cost the owner of it. Nor is this practice so unallied to a fault, as to escape a punishment even in this world; these courtiers of applause being oftentimes reduced to live in want, even in the midst of a plentiful fortune; these costly trifles so engrossing all that they can spare, that they must sometimes deny themselves things convenient, and, perhaps, almost necessary, to flaunt it out with those, that are neither the one nor the other, and being frequently enough fain to immolate their own inclinations and desires, though, perchance, strong and innocent, to their vanity.

And

And those, that have once found the happiness there is in making others happy, will think their treasure better bestowed in feeding hungry mouths, than idle eyes: the costly practice I am yet censuring, does not only offend charity, but starve it, by subtracting from it that, which should feed it, and enable it to act like it self. And for my part, I think, he, that devises, and by his example brings credit to, a new expensive way of vanity, does really destroy more poor, than if he usurped an alms-house, or ruined an hospital. And by the ill precedent he leaves, he takes the way to be uncharitable, even after death, and so do harm, when misers and usurers themselves are wont (by their legacies) to do some good. To conclude, it is no very Christian practice to disobey the dictates of piety, without having so much to plead for so doing, as the pretence of following the dictates of custom: and it is a great deal better to be without a gay closet, than to be without charity, which love-liest of Christian virtues she must sure very much want, that will needlessly begin a new example to give a bad one.

REFLECTION X.

Upon his seeing a lark stoop to, and caught with, day-nets.

EUSEBIUS, LINDAMOR.

EUSEB. **P**OOOR bird! thou wert just now so high upon the wing, that the tired gazers feared thou hadst lost thy self in heaven, and in thy fatal stooping seemest to have brought us thence a message, that so relishes of that place, that I should be troubled to see thee so rudely entertained, if that circumstance were not necessary to the instructions of thy message. Some birds, you know, *Lindamor*, we usually beguile with chaff, and others are generally drawn in by appropriated baits, and by the mouth, not the eye. But the aspiring lark seems composed of more sprightly and refined materials; she is ever a natural, though no native, Persian; and the sun makes not a cloudless visit to our horizon, which that grateful creature gives not a welcome to, both by notes, which, could he hear them, he would think worthy of him, and by a flight as aspiring, as if she meant he should hear them; and, in a word, so conspicuous is this creature's fondness of light, that fowlers have devised a way to catch her by it, and pervert it to her ruin: for placing broken looking-glasses upon a moveable frame betwixt their nets, the unwary bird, while she is gazing upon that glittering light the glass reflects, and sporting herself in those beams, which derive a new glory from their very being broken, heedlessly gives into the reach of the surprizing nets, which suddenly cover her, and which the light itself kept her from seeing. The devil is like this fowler, *Lindamor*; and you, or I, had perhaps resembled the unhappy lark, if sometimes providence did not both graciously, and seasonably, interpose, and even when we were come near enough to have been covered by the nets, rescued us from them; for it has ever been that old serpent's policy, and practice, to take the exactest measure of our inclinations, that he may skilfully suit his temptations to them; well knowing, that that dexterity gains him a devil within us, that conspires with him without us; to make us instances of that truth, which represents things divided against themselves as ruinous. If therefore the tempter find by experience, that you are indisposed to be wrought upon by common temptations, to forget the practice of religion, that you have unconcernedness enough not to be much distracted with the empty and trifling chaff, youth is wont to be caught with, (which perhaps seldom employ any of your thoughts so much as those of scorn, and pity) that the very gain and solid goods of this world (for which many, thought wise men, lose

lose those of the next) cannot make you so greedy, nor so fond of them, as he desires: if, I say, the devil have sufficiently observed, how uneasy it were to intice you with common baits, he will alter his method strait, and attempt to catch you with light. He knows as well as I do, that you have a curiosity, or rather a greediness of knowledge, that is impatient of being confined by any other limits than those of knowledge itself; and accordingly, seldom, or perhaps never disturbing or frightening you, he will let you freely sport your self about the glittering intellectual glass, men call philosophy, and suffer you not only to gaze upon all its pieces, and survey a pretty number, but, peradventure, pry into more than one: and among so numerous, and delighting objects, I fear, that if you will frankly own what my own guilt makes me suspect you of, you must confess, that he had made you so share your time, that you should scarce have left your self any for heavenly themes, and the meditation of death, (which consequently, might have then surprized you, had it invaded you) if providence had not mercifully snatched you out from between the nets you were allured to, before you were quite involved in them; and by sickness, or else, by means (in other cases) so unlikely, as outward distractions, called your thoughts home by driving them away from those enchanting studies, whose light might much likelier have betrayed you into the net, than have shewn it you.

LIND. Though I am not surprized to hear *Eusebius*, yet I am glad to hear a scholar talk at this rate, and believe with you, that many a one, that was neither crow, nor woodcock, has perished in this snare; and we have known but too many great scholars so intirely taken up with writing, and reading of books, with learning this science, and with teaching that, that by setting themselves such tasks, as required and employed the whole man, death has undiscernedly stolen upon them, and unawares intruded into their studies, where their restless ambition to enrich the mind never left them the leisure to prepare it to leave the body, but either made them surprized instances of that sad (but true) observation of *Seneca*, *plerosque in ipso vitæ apparatu vita destituit*; or else made their condition like that of *Archimedes*, who was so busy in tracing his circles, that he took no notice of that victorious enemy, that came to dispatch him.

EUSEB. I allow, that it is the innocence, as well as pleasure of knowledge, that deceives those learned men; but they, as well as others, must remember, that even the wholesomest meats may be surfeited on, and there is nothing more unhealthy, than to feed very well, and do but very little exercise. And I take it to be as true of the intellectual, as the material world, that *it profits not a man, if he gain the whole world, and lose his own soul*. Whatsoever therefore philosophers do tell us of a wise man, that he is no where banished, because he is a citizen of the world; I must think a Christian every where an exile, because he is a citizen of the heavenly *Jerusalem*, and but a *stranger and a sojourner here*. It was not absolutely in the capacity of the *father of lies*, that the devil boasted, that the earth was his dominion; for, as our Saviour stiled him, *the prince of this world*, I find, that he has all things here so much at his devotion, that there is no place, that he cannot lay an ambush in, since he can pervert even light itself, to hide his snares. Let us, therefore, hereafter endeavour still to stand upon our guard, as remembering our selves to be in an enemy's country, where distrust is the only mother of safety; and since providence has so graciously presented us a lesson, our books would not have taught us, against such a fondness of them, as is injurious to piety, and dangerous to the soul; let us justify, better than this silly lark has done, that saying of *Solomon*, *surely in vain the net is spread in the sight of any bird*. Let not philosophy any more take up our life so, as not to leave us leisure to prepare for death, and study a science, which shall most benefit us in another world,

world, and which alone will do so there. No, we may visit *Athens*, but we should dwell at *Jerusalem*; we may take some turns on *Parnassus*, but should more frequent mount *Calvary*; and must never so busy our selves about those *many things*, as to forget that *unum necessarium, that good part, which shall not be taken away from us.*

OCCASIONAL REFLECTIONS.

THE LAST SECTION.

REFLECTION I.

Seeing a child picking the plums out of a piece of cake his mother had given him for his breakfast.

EUSEBIUS, LINDAMOR.

EUSEB. **T**HIS child is so much one in his humour, that despising meer bread, though never so nourishing and wholesome, his mother is fain to disguise the materials of it into cake, out of a belief, that the toothsome would make the nutritive part go smoothly down. But this liquorish chit, I see, defeats her plot, and knows already how to nibble off the bait from the hook, and casting by the meat, makes his whole meal of what was meant only for sauce, to give a relish to what he rejects for it. This puts me in mind of the unwelcome fate those papers of mine, that treat of devotion, have met with: for when I first was so unacquainted with the world, as to expect, that piety and virtue were able, by their native charms, so much to endear my dress, as to win themselves adorers in a plain, or even a severe one; I ventured some of them abroad, though not in print, yet among my acquaintance, in a careless matron-like habit, in which I soon found they almost frightened most of those I had designed them to work the quite contrary effects on. But when my acquaintance with the genius of the age had sadly taught me, that I was to alter my method, that the eloquence of virtue's sermons was that, which must attract an auditory, and engage attention to them; and that those orders of hers, in which she employed not rhetoric for her secretary, could not be so much as listened to, much less obeyed, I endeavoured to cloath virtue, though not in a gaudy, in a fashionable habit, and divesting her not only of her sack-cloth, but her blacks, where I saw she appeared in them with disadvantage, I endeavoured to give her as much of the modern ornaments of a fine lady, as I could, without danger of being accused to have dressed her like a courtesan. This attempt having not proved so unsuccessful, but that many were pleased to assure me, I had not been unlucky in it, I spent some time in the self-denying exercise of minding words, and improving a style, I hoped to be able to improve to virtue's service, and subduing my inclinations to be fit to teach, as I had done to learn, her precepts; I sometimes, for her sake, tried my pen in a smoother, and more florid style, than that, which the nature of the studies I was most addicted to, made the most familiar to me, flattering myself with a belief, that since my writings had usually the good fortune not to be ill approved, I might so happily mingle and interweave instructions with delight, as to necessitate my readers to swallow both together, or at least bribe them by the latter to entertain the former.

LIND.

LIND. You have better luck, as well as better skill, than many others, if you find it not often to fare with the fishers of men, as it did with those other fishers, that first were honoured with that glorious title, when they complained to our Saviour, that *we have toiled all the night, and have taken nothing.* For I see, that men are grown witty enough to elude what they cannot despise, and resemble the deaf adder, that stops her spiritual ears from hearkening to the voice of charmers, be the charmer never so cunning. And the best reception, that the movingest eloquence, that pleads for piety, can obtain of them, is but such as may serve to make that applicable to the preacher, which God once said to a prophet, *Lo, thou art unto them as a very lovely song of one, that hath a pleasant voice, and can play well upon an instrument; for they hear thy words, but they do them not.* But the best is, that you serve a master, that is as inclinable to reward, as able to discern, intentions, and does not make his estimates by events, but judges of our performances, not by the effects they produce, but the affections they flowed from, and the ends they aimed at.

EUSEB. *The disciple is not above his master, nor the servant above his lord.* And therefore, *Lindamor*, as I dare not repine at the unsuccessfulness of my endeavours, so I dare think, that whilst it proceeds but from the obstinacy of others, it is not likely to be imputed to me by him, that complained himself, *that all the day long he had stretched forth his hands to an unpersuadable and gain-saying people.* Otherwise, I confess, I should not have much cause to be satisfied with the return, that all my endeavours have hitherto brought me home. For I see, that men can read a book of devotion as unconcernedly as they do a romance or a play, in both of them culling out only what they call wit, and making no better use of it than either to exercise or improve their own. They hear the most pathetick sermons, not as Christians but orators; and if in such discourses they have been so just as to praise the rhetorick, they think they may well be excused, if they over-look the divinity: in short, nothing but what gratifies their fancy can leave any impressions on their memory, and that itself, if it tend to reform them, makes none on their affections. And some, whose happier pens allow them to do it far more justly than I can, do complain, that if a devout book have not good store of witty passages, they will not mind it at all; and if it have, they will mind nothing else.

So that, *Lindamor*, I should sometimes be discouraged from prosecuting endeavours, which though they now and then succeed, are oft-times so unprosperous, if I did not think with you, that they, who labour to win souls to God, are set on work by him, that having no need of our performances, seeks in our services but the opportunities of exercising his own goodness.

REFLECTION II.

Upon the sight of sweet-meats very artificially counterfeited in wax.

THE shape and colours of the best sweet-meats of these kinds are here so luckily represented by a skilful hand, that art seems to have designed rather to rival nature, than barely to imitate her, and a lover of junkets, that approaches not too near to these, must have much quickness of sight, or but little of appetite, if such inviting objects do not tempt him both to mistake and to desire them. But, though at this distance these alluring sweet-meats appear very pleasing, yet if one should be so unadvised, as to endeavour to eat them, instead of injoying them more fully by the taste than he did by the sight, he would both spoil and disfigure them, and perhaps be so near choaking himself, that he would more earnestly wish them out of his mouth, than ever he wished them in it.

THERE are some pleasures and conditions too in the world, which make so fine a shew at a distance, that in those, that gaze at them aloof off, they frequently beget envy at them, and wishes for them; and yet he, that calmly beholds them, takes the best way of injoying them: since that, which, whilst it is but aimed at, is expected to be very satisfactory upon a nearer and fuller fruition, would be so far from proving so, and would so little be as sweet to the palate as specious to the eye, that it would not only cease to afford them any delight, but would make them wish they had let those deluding sweets alone, and would make attainments more uneasy and troublesome, than even desire was.

REFLECTION III.

Upon the eating of oysters.

EUGENIUS, LINDAMOR.

EUG. **W**HILST every body else is commending these oysters, either with his tongue or with his teeth, so that one of the company sticks not to say, that they are as much worth, as if they contained each of them a pearl, you only seemed as unconcerned a spectator, as if you thought their proper use, like that of flowers, were rather to be looked on than to be eaten.

LIND. I confess, *Eugenius*, that I found my self more inclinable to reflect on what you are doing, than to keep you company in it; and whilst I saw such persons so gustfully swallow these extolled fishes, the sight led me to take more notice than perhaps you have done of the strange power of education and custom.

EUG. And what, I pray you, has custom to do with oysters?

LIND. You will soon know that, if I tell you, that I was considering, on this occasion, how forward we are to think other nations absurd or barbarous for such practices, that either the same, or little better, may be found unscrupled at among our selves; and I acknowledge it to be one of the chief advantages I account my self to have obtained by my travels, that as I do not easily admire, so I am not forward to deride, the practice of any people for being new, and am not apt to think their customs must be therefore worse than ours, because they widely differ from them.

I COULD give you store of instances to justify this impartiality; but because the circumstances of eating and drinking are those, which make men, with the greatest confidence, term other nations brutish and barbarous, I will confine my self to some examples of that nature.

WE impute it for a barbarous custom to many nations of the Indians, that like beasts they eat raw flesh. And pray how much is that worse than our eating raw fish, as we do in eating these oysters? Nor is this a practice of the rude vulgar only, but of the politest and nicest persons among us, such as physicians, divines, and even ladies. And our way of eating seems much more barbarous than theirs, since they are wont to kill before they eat, but we scruple not to devour oysters alive, and kill them not with our hands or teeth, but with our stomachs, where (for aught we know) they begin to be digested before they make an end of dying. Nay sometimes when we dip them in vinegar, we may, for sauce to one bit, devour alive a shoal of little animals, which, whether they be fishes or worms, I am not so sure, as I am, that I have, by the help of convenient glasses, seen great numbers of them swimming up and down in less than a saucer full of vinegar.

WE detest and despise some other nations, for feeding upon caterpillars, grasshoppers, and other insects ; and others for feeding upon carrion, and stinking food.

AND do not many of us do as bad, when we not only eat, but extol, rotten cheese, whose livid colour sufficiently betrays its putrefaction, and whose odious smell offends most men's noses, and turns some men's stomachs ? Nay, when this cheese is grown to that high degree of rottenness, that our critical palates like it best in, we then devour whole hundreds of mites, which are really crawling insects, bred out of putrefaction, and these too are so numerous and little, that our greediness makes us swallow many of them alive.

AMONG the savagest Barbarians we count the Cannibals ; and as for those among them, that kill men to eat them, their inhuman cruelty cannot be too much detested ; but to count them so barbarous, merely upon the score of feeding upon man's flesh and blood, is to forget, that woman's milk, by which alone we feed our sucking children, is, according to the received opinion, but blanch'd blood ; and that mummy is one of the usual medicines commended and given by our physicians, for falls and bruises, and in other cases too. And if we plead, that we use not mummy for food, but physick, the Indians may easily answer, that, by our way of using man's flesh, we do oftentimes but protract sickness and pain ; whereas they by their's maintain their health and vigour. And there is no reason, why it should be allowable to eat broth, for instance, in a consumption, and be condemn'd to feed upon it to maintain health.

BUT lastly, as the highest degree of brutishness, our travellers mention the practice of the Soldanians, at the *Cape of Good Hope*, who not only eat raw meat, but, if they be hungry, eat the guts and all of their cattle, with the dung in them. I will not answer, that I know several among us, (and perhaps some fair ladies too) that, to prevent the scurvy and the gout, drink their own or boy's urine : nor that women themselves do oftentimes take parmacitty inwardly, though the Latin name (*Spermaceti*) sufficiently declare what excretion of a whale it is (though perhaps mistakenly) believed to be : nor yet, that under the name of *Album Græcum*, dog's dung is commonly given to patients of all sorts and qualities, against sore throats : nor will I mention, that in *Holland* it is usual, as I have seen my self, to mingle sheep's dung with their cheeses, only to give them a colour and a relish. But I will rather demand, how much less we do ourselves, than what we abominate in those savages, when we devour oysters whole, guts, excrements, and all ? nay, when not for physick, but only for delicacies, our courtiers and ladies themselves are wont to make sauce for the bodies of lobsters of that green stuff, which is indeed their dung. And to these I could add other examples, if I were not afraid to divert you too long from so much pleasure, as the company seems to take, in eating raw fish.

EUG. You put me in mind of a fancy of your friend Mr. Boyle, who was saying, that he had thoughts of making a short romantick story, where the scene should be laid in some island of the southern ocean, governed by some such rational laws and customs, as those of *Utopia*, or the *New Atlantis* ; and, in this country, he would introduce an observing native, that, upon his return home from his travels made in *Europe*, should give an account of our countries and manners, under feigned names, and frequently intimate in his relations, (or in his answers to questions that should be made him) the reasons of his wondering to find our customs so extravagant, and differing from those of his country. For your friend imagined, that by such a way of proposing many of our practices, we should ourselves be brought unawares to condemn, or perhaps laugh at them, and should at least cease to wonder, to find other nations think them as extravagant, as we think the manners of the Dutch and Spaniards, as they are represented in our travellers books.

LIND. I dislike not the project, and wish it were prosecuted by somebody, that, being impartial, were more a friend to fables. For when I consider, that the name of Barbarian was given by the two noblest people of the earth, the Greeks and Romans, not only to all the rest of the world, but to one another, though both those nations were highly civilized, and the courtly Persians, and other voluptuous Asiatics, were perhaps no less so than they; I doubt, that most nations, in styling one another's manners extravagant and absurd, are guided more by education and partiality, than reason; and that we laugh at many customs of strangers, only because we never were bred to them, and prize many of our own, only because we never considered them. And we may well believe, that custom has much a larger empire, than men seem to be aware of, since whole nations are wholly swayed by it, that do not reckon themselves among its subjects, nor so much as dream, that they are so.

REFLECTION IV.

Upon a lanthorn and candle, carried by on a windy night.

AS there are few controversies more important, so there are not many, that have been more curiously and warmly disputed, than the question, whether a publick or a private life be preferable? But perhaps this may be much of the nature of the other question, whether a married life or single ought rather to be chosen? that being best determinable by the circumstances of particular cases. For though, indefinitely speaking, one of the two may have advantages above the other, yet they are not so great, but that special circumstances may make either of them the more eligible to particular persons. They, that find themselves furnished with abilities, to serve their generation in a publick capacity, and virtue great enough to resist the temptations, to which such a condition is usually exposed, may not only be allowed to embrace such an employment, but obliged to seek it. But he, whose parts are too mean to qualify him to govern others, and perhaps to enable him to govern himself, or manage his own private concerns, or whose graces are so weak, that it is less to his virtues, or to his ability of resisting, than to his care of shunning the occasions of sin, that he owes his escaping the guilt of it, had better deny himself some opportunities of doing good, than expose himself to probable temptations. For there is such a kind of difference betwixt virtue, shaded by a private, and shining forth in a publick life, as there is betwixt a candle carried aloft in the open air, and inclosed in a lanthorn; in the former place it gives more light, but in the latter, it is in less danger to be blown out.

REFLECTION V.

Upon the first audience of the Russian extraordinary ambassador, at which he made his emperor's presents.

I SEE the general expectation, that there will be here this night a magnificent appearance, has produced one. And, as it often happens in publick shews, that the chief part of them is made by those, that come to see them; so here, besides them, whose duty obliges them to attend at the solemnity, there is a greater concourse of fine people of either sex, than any thing of this nature has for these many years occasioned. And not only many of the ladies wear in their ribbands little less vivid colours, than those of their faces, and are set out with jewels almost as sparkling as their eyes, (which yet the courtiers think were able to warm the Russian hearts, though all the ice

and snow of their country guarded them) but the men themselves are many of them as finely and as richly dressed, as if even they came as well to be seen as to see. And if the ambassador be, what a man of his employment should be, (and what some say he is) a person acquainted with the manners of men, he cannot but know, that we, as other nations, value our own fashions enough, to look upon men disguised by the Russian dress, as little better than anticks, if not as some new kind of northern animals. But for all this gazing throng of gaudy spectators, that were able to put an ordinary stranger out of countenance, to appear in a habit differing from their's; the ambassador, and those, that come along with him, think it not fit to decline the Russian habit or ceremonies for the English, but keep to the ceremonies used in *Muscovy*, as strictly, as if the monarch of it, that sent him hither, saw them here; and are not discouraged from this manly proceeding, by seeing themselves stared at for it by a number of gaudy spectators, that wear clothes, and use ceremonies, so differing from their's. And whatever those may think of the ambassador, that are wont to estimate men by the fashionableness of their clothes; yet the wiser and more intelligent do not blame him, for refusing to disparage the fashions of his own people, by appearing ashamed of them; but do rather think it prudent in him, to prefer the pleasing of his master, and his own countrymen, before the gratifying of strangers, since it is not here, but at home, that he expects the recompence of his behaviour, and embassy.

Thus, when a Christian, who belongs to a celestial king, and whose *citizenship is in heaven*, being but a *stranger upon earth*, converses among the *men of the world*, though in matters indifferent, there is oft-times required by prudence as much of compliance, as is allowed by innocence; yet, when there happens an occasion, wherein he cannot comply with the depraved customs of those, among whom he lives, without disobeying him, for whom he lives, and whose servant he is, or doing something, that would derogate from the dignity of a person related to such a master, he will then less consider, what may be thought of him by a multitude, than what account he is to render to him, who has forbidden men *to follow a multitude to do evil*. And as he knows, that his reward would be much less than he reckons upon, if it were a thing to be received on earth, not in heaven; so, how strange and unfashionable soever his conformity to the orders of his own sovereign may appear, he chuses rather to displease men than God, and acts, as both *seeing*, and being seen by, *him that is invisible*.

A continuation of the DISCOURSE.

AND this ought to be more easy to him, than their singularity is to the Russians, I have been mentioning; for whereas these, if they be knowing, and impartial, refuse our modes and rites, not because they are worse, but only because they are other than those of their country; he refuses to conform to the forbidden fashions of this world, not for their being different from those of the kingdom he belongs to, but for their being bad, and condemned by him, that cannot err: whereas, of the opposite practices, the same infallible judge pronounces, by the mouth of a person by him inspired, that *these are the good things, and the profitable unto men*. And whereas these strangers see nothing in this magnificent assembly, whose fashions they decline, fit to be despised, but see some persons in it, to whom they pay a great respect, and who deserve it upon another account, than that of their wearing crowns; those, that are loyal to virtue, have cause to look upon those they refuse to be like, with a noble, and just indignation, as persons that have degraded themselves, and by unworthy practices blemished, and almost forfeited, the dignity of their nature, and the nobler title of Christians. And, whereas these Muscovites are morally certain, that we shall never

never prefer their fashions to our own, the Christian has as great an assurance, that those, whose practices he dissents from, will one day repent, that their's dissented from his, and will wish they had imitated what they now seem to scorn. And however, when he shall come to the celestial city he belongs to, he will be in no danger to be derided for the sake of piety, since those, that deride piety, will not be admitted there. And as these Russians could not take a better way, than that of not sneaking, to avoid the having their rites and persons undervalued; so for a Christian not to blush at his unfashionable practices, seems the hopefullest way to keep them and him from being scorned, especially with those, who having themselves no quality better than confidence, value it most in others. And sure it were a very unlikely way, to keep others from despising the customs of the heavenly *Jerusalem*, for him, that belongs to it, to appear ashamed of them himself. Nor have pious persons cause to be out of countenance, at the singularity even of a strictly virtuous deportment, since, being (as the Scripture tells us such men in general are) *fellow-citizens with the saints and domesticks of God*, they cannot justly be blamed, if they aspire to be as like as they can here, to those, whom they desire and hope to be perfectly like hereafter. And if the angels (as the Scripture in several places seems to intimate) are witnesses of our actions, the smallest number of unfashionable good men may, upon that score, say to one another, as the Prophet did to his servant, upon the account of the heavenly host that surrounded him, *Fear not, for they that be with us are more than they that be with them*. And the approbation of these illuminated, happy, and glorious spirits, is sure more considerable than that of mortal, and, which is worse, of sensual men, whether we consider their number, or their judgments. And however, the day will come, when those, that despise their singularity, will envy his happiness; one welcoming smile from Christ will make him amends for all the scornful smiles of sinful men; and the sentence of absolution, and bliss, solemnly pronounced before God, angels, and men, will not only recompense him for the world's dis-esteem, but shew, that he did not deserve it.

2 Kings
v. 16.

REFLECTION VI.

Upon the sight of roses and tulips growing near one another.

IT is so uncommon a thing to see tulips last till roses come to be blown, that the seeing them in this garden grow together, as it deserves my notice, so methinks it should suggest to me some reflection or other on it. And perhaps it may not be an improper one, to compare the difference betwixt these two kinds of flowers, to the disparity, which I have often observed, betwixt the fates of those young ladies, that are only very handsome, and those that have a less degree of beauty recompensed by the accession of wit, discretion, and virtue: for tulips, whilst they are fresh, do indeed by the lustre, and vividness, of their colours, more delight the eye than roses; but then they do not alone quickly fade, but as soon as they have lost that freshness, and gaudiness, that solely endeared them, they degenerate into things not only undesirable, but distasteful; whereas roses, besides the moderate beauty they disclose to the eye (which is sufficient to please, though not to charm it) do not only keep their colour longer than tulips, but when that decays, retain a perfumed odour, and divers useful qualities, and virtues, that survive the spring, and recommend them all the year. Thus those unadvised young ladies, that because nature has given them beauty enough, despise all other qualities, and even that regular diet, which is ordinarily requisite to make beauty it self lasting, not only are wont to decay betimes, but as soon as they have lost that youthful freshness, that alone endeared them, quickly pass

pass from being objects of wonder, and love, to be so of pity, if not of scorn; whereas those, that were as solicitous to enrich their minds, as to adorn their faces, may not only with a mediocrity of beauty be very desirable, whilst that lasts, but notwithstanding the recess of that, and youth, may, by the fragrant of their reputation, and those virtues and ornaments of the mind, that time does but improve, be always sufficiently endeared to those, that have merit enough to discern and value such excellencies; and whose esteem and friendship is alone worth their being concerned for. In a word, they prove the happiest, as well as they are the wisest, ladies, that whilst they possess the desirable qualities, that youth is wont to give, neglect not the acquit of those, that age cannot take away.

REFLECTION VII.

(Taken out of the 2^d book of the * martyrdom of *Theodora*, and turned into an Occasional Meditation.)

* An unpublished piece of the author's.

Upon the sight of a branch of coral among a great prince's collection of curiosities.

THE present and future condition of a Christian, especially of a martyr, is not ill represented by what we take notice of in coral; for whilst that shrub yet lives, and remains fastened to its native earth or soil, it grows in an obscure region of the world, and is perpetually surrounded, and over-flown, by the brackish and unpleasant waters of the sea, and oftentimes exposed to the irregular agitation of its waves. Besides, the substance of this plant (as those that should know inform us) is but soft and tender under water, and its colour but sad and unlively: nor is it, like the tulip or the rose-bush, adorned with any pleasant verdure, and much less does it flourish with gaudy colours. And whilst it remains under water, the excellency of it does so little disclose it self, that men sail over it without suspecting or dreaming they have any thing of precious under their feet; and by the fishes, in whose region, or rather element it grows, it is passed by wholly unregarded: but when this unheeded coral comes to be torn off from its root, and plucked out of his soil, and so is killed in the capacity of a plant, it then exchanges the dark and unquiet place it was confined to, for a more elevated and lightsome region; and instead of sharing the fate of common shrubs and flowers, first to degenerate into fading colours and offensive smells, and then to perish, either by rottenness or fire, our coral, by the violence offered to it, acquires a delightful redness, together with a solidity and a durableness, that makes it a thing so lovely and immortal, that it serves for an ornament for the cabinets of the curious; and what stupid fishes do not at all regard, those nobler creatures, men, do so highly prize, that oftentimes it finds place even among the rarities of princes.

Thus, a true Christian, whilst he is yet confined to the region of the animal life, lives oftentimes in an obscure and low condition, and far from that prosperous state, wherein the world's favourites are wont to flourish: he is almost perpetually exposed to pressures and afflictions; and either most men consider him not at all, or those, that look at his outside only, are apt to despise him, because it is so homely. And he is not only in such a (seemingly forlorn) condition, as made the Psalmist complain of himself, that *all the waves passed over him*; but (like those plants of coral, that, not growing so near the shore, are constantly covered with water, as well as sometimes disordered by storms) the calamities, that do, as it were, overwhelm him, are never altogether removed, even in the intervals of those tempestuous fits, which increase his distresses: but when the violence of sickness, or the fury of a persecutor shall

2 Cor. v.

4.

αὐτὸ θνήσκει.

Mal. iii.

17.

• Segullah.

2 Joh. iii.

2.

shall have taken away his life, he must be then translated into a higher and happier region, afflictions and distresses will be all left behind. And when the sensual idolizers of their bodies shall be condemned to have those as loathsome as were their minds, and as restless as their guilty consciences, his body will obtain new and glorious qualities like that of his redeemer, and his soul shall find no less happy a transfiguration; the mortal part will be swallowed up of life, that perfection, which is but in part, shall be done away. And these newly acquired excellencies of the whole man will never after vanish or decay. And he, that lived unregarded by the stupid inhabitants of the earth, shall be joyfully welcomed into the blest society of celestial spirits; and, what is infinitely more, be graciously welcomed and dignified by the Son of God himself. Men should not therefore, by a Christian's present state, take their measures of his future fate, but rather should remember, that he, who said of such, *They shall be mine in the day when I make up my * special treasures*, is one, whose estimate of persons and conditions we may safely rely upon, since he is able to make any of them infallibly such as he pleases to pronounce them, and consequently we may look upon the constant Christian's differing condition, with his eyes, that said, *We are now the sons of God, and it does (not indeed) yet appear what we shall be, but we know, that when he shall appear, we shall be like HIM*; who would be like himself alone, did not his goodness vouchsafe to exalt those that love him, to a likeness, which makes them very unlike the gloriouslest things we here admire, by incomparably transcending them.

REFLECTION VIII.

Upon the sight of the effects of a burning glass.

IT is a fault incident to many good men, to be too much indisposed to entertain the precepts of virtue, as such excellent things deserve, in case those, that teach them, do not practise them. There are too many, that do not think themselves obliged to take even the wholesomest advice from those, whom they see more careful to give it others, than to follow it themselves. And some of them are so nice, that they will scarce read a book of devotion, unless it come, like that St. John eat in the *Apocalypse*, from the hand of an angel. But for my part, though I hope I both value and desire religious preachers as much as the rest of my brethren, yet I think it would be much to the injury of Scripture and of reason, if we should suffer the personal faults of men to keep them from doing that good, their nature fits them for. The etymology of the gospel importing its being welcome news, it is pity, that any one that teaches it should not have a title to the character David gave Abimaaz, of whom he said, that *he is a good man, and brings good tidings*. But my desirousness of piety in a preacher is more for others sake than mine. For I know not why truth, which is an intellectual thing, should lose its nature by any moral viciousness in the proposer. I know there is something extraordinary in the case of Noah, who awoke from his wine, and immediately prophesied, and yet the event verified his predictions. Our Saviour instructing his disciples about the Scribes and Pharisees, who sat in Moses's chair, at the same time commands them to conform to their doctrine, when he forbids them to imitate their example. The wise-men did not the less find Christ at Bethlehem, though the priests and Pharisees sent them without accompanying them thither. And the Assyrian general was cured of his leprosy by following the Prophet's prescription conveyed him by that Gebazi, who, by his unworthy carriage in that business, transplanted (if I may so speak) that foul disease into himself and his posterity. I will therefore consider sermons more than preachers: for as in a burning-

glass,

glass, though the sun-beams do but illustrate, not heat, it in their passage, they may yet, by its assistance, kindle subjects, that are more disposed to receive their action: so those very truths and notions of a learned preacher, which do but enlighten him, may inflame his hearers, and kindle in their hearts the love of God. And as if a perfume be set on fire by the beams projected through a burning-glass, (which they do not so much as warm in their passage) the scent is no less odoriferous and grateful, than if it had been produced by an actually burning coal. So neither is that devotion, which is kindled by the eloquence of an indevout preacher, any whit the less acceptable to God for their not being themselves affected with the zeal they beget in others. And what the book of *Kings* relates of *Elisba's* bones, contains a far greater miracle in the historical, than in the allegorical sense, in which it is no such wonder to see a man raised to life by a dead prophet.

REFLECTION IX.

Upon the finding a horse-shoe in the high-way.

THE common people of this country have a tradition, that it is a lucky thing to find a horse-shoe. And though it was to make my self merry with this fond conceit of the superstitious vulgar, I stooped to take this up; yet now I observe in it a circumstance, that may, for aught I know, somewhat justify the tradition. For I take notice, that though horse-shoes are by travelling worn out, yet if they had a sense of their own condition, it might afford them some consolation in it, that the same journies, that waste them, make them both useful and bright. Whereas, though the horse-shoe I have taken up have not been consumed upon the account of travelling, it has been eaten up by rust, which wastes it as well as attrition would have done, but does not give it the lustre it would have received from that. I meet with many, who, very unmindful, that he, who was justly styled the wiseman, whose counsel it was, that *what ever our hand finds to do, we should do it with all our might, &c.* make it the main business of their life merely to lengthen it, that are far more solicitous to live long, than well, and would not undergo the least labour, or endure the least hardship, to do the greatest good, but had rather lose an hundred opportunities of serving God, or obliging men, than an entertainment, or an hour's sleep, and all this under the pretence of minding their health, and complying with the dictates of self preservation. But I have often observed too, that even these jolly people, that seldom have a serious thought, but how to avoid serious employments, may, by making their whole lives a succession of diversions, or rather a constant diversion from the true end of them, make their lives indeed thereby useless, but not at all immortal. And truly, fevers, pleurisies, and other acute diseases, that are home-bred, besides those numerous fatal ones, that are caught by contagion, and a multitude of casualties, do cut off so many before they reach old age, in comparison of those, that the diligence, and industry, imposed by religion, or curiosity, destroy, that I think so great a fear of using the body for the interests of the soul, and of him to whom we owe both, does very little become his disciples, who said, that it was *his meat to do the will of God that sent him, and to accomplish his work.* The trouble of thirsting, and sweating, and undressing, would to an ingenious man be but just recompensed by the bare pleasures of eating, and drinking, and sleeping: to confine an honest and inquisitive person from those, which he looks upon as the almost only manly employments, the exercise of virtue, and the pursuit of knowledge, by telling him, that such a forbearance may protract his life, is to promise a thing upon a condition, that destroys the end and use of it; and he will look upon it, as if you should

John iv.
34

offer him a horse, provided he will not ride him, or a perspective-glass, upon condition he shall not draw it out, for fear the air should, as it sometimes does, impair the glasses. A heaven-born soul would scarce think it worth while to stay here below, if its work must be, not to employ the body, but to tend it. Those, that are so unreasonably afraid to spend their spirits, are in some regards less excusable than misers themselves; for though both hoard up things, that cannot be better enjoyed, than by being parted with, the chief uses for which they were intrusted with them: yet in this, those I blame are more censurable, than the covetous themselves, since these, by their niggardliness, can avoid spending their money, but the others, by their laziness, cannot avoid the consumption of their time. I know a man may be prodigal of himself, as well as his estate; and that both those profusions are faults, and therefore fit to be declined. But if I could not shun both the extremes, certainly, since we all must die, and the question is not, whether or no we will live for ever, (for the most, that can be hoped for, is not to be privileged from death, but only to be longer reprieved) but whether we will rather endeavour to lead a life, mean, and unprofitable, a few more days, or a glorious life, for a somewhat less number of them? I should rather chuse to spend my life quickly, than uselessly; for he, that lays out himself for eternity, if he lose any portion of his time upon that account, is the sooner put into possession of an inexhaustible stock of it; whereas those, who, that they may live long, meanly forego the ends of living, and seek, by laziness, to protract an insignificant stay on earth, would, should they reach their aim, add rather to their years than to their life.

REFLECTION X.

At the
Hague.

Upon the shop of an ugly painter rarely well stored with pictures of very handsome ladies.

GENORIO, EUSEBIUS, LINDAMOR.

GENOR. **H**ERE is a deceitful shop of beauty, where many, that come but to wonder, meet with love, and even when they buy not what they like, pay their hearts for it; the shop being so well furnished, that beauty seems here to have assumed all the variety of features, and complexions, she can be dressed in, and so exquisitely to have fitted all gazers with proportionate and attractive objects, that nothing but an absolute incapability of love is here able to protect them from that passion, which, not to resent among so many inspiring wonders, were one. If in these faces, the originals equal the transcripts; if art have not flattered nature, and attempted more to instruct than imitate her; and if the painter have not elected, rather to have his pieces liked, than like, here are apologies for love, that can procure it, not only pardons, but proselytes. I must (in that case) add, that there are more suns than one, whose brightness, even by reflection, can dazzle; here are princesses more illustrious for the blood, that lightens in their cheeks, than for that, which runs in their veins, and who, like victorious monarchs, can conquer at a distance, and captivate by proxy.

EUSEB. I fear, *Genorio*, that you are so transported with your text, that you will quite forget (if ever you intended it) to make a homily upon it: for you talk at such a rate, as if you were about to lose, to the pictures of ladies, the liberty, your friend *Mr. Boyle* would be thought to have ever defended against their originals, and fancied, that it might add to the other resemblances you so admire betwixt them, if both of them were made enemies to seriousness.

LIND.

LIND. I presume, *Genorio* will willingly allow me to serve him at this turn: for whether or no he meant us a reflection, some charms or other he has met with in these pictures, seem to have so arrested his thoughts, as well as his looks, that we shall not have them hastily delivered from so pleasing a captivity; and the knowledge I alone, of us three, have of the drawer of these pictures, supplies me with a circumstance, without which, I should not, when *Eusebius* is by, offer at an occasional meditation. But upon this advantage, I shall venture to tell you, that the thing I was considering, was, that though the limner have drawn some pieces, as handsome as lovers think, or with their mistresses, and some (as they tell me) so like, that an actual confrontation of the artist's works, and nature's, would scarce distinguish them, (since the former would appear to differ from the later, but in that silence, which the later's admiration, to see themselves so perfectly represented, would impose) yet is the painter himself so deformed a creature, that he might draw a lovelier face even than any here, by drawing one perfectly unlike his own. Alas! this discloses the difference there may be betwixt the being able to write fine characters of virtue, and the possessing of it. How ridiculous should I esteem this limner, if with all his ugliness, he should esteem himself handsome, because his pencil can draw faces that are so! As absurd were it for us, to grow proud of our devout composures, and fancy piety ours, because our discourses can possibly inamour others of it. The devil sometimes does unmolestedly suffer us to write well, if he can but persuade us we need do no more, and that good pens may dispense us from good actions. Our paper-wars against vices are oftentimes like *Alexander's* against the neighbouring nations, not out of hatred, but glory, not to extirpate, but to conquer them, and manifest to the world the sufficiency of our parts, by a victory, after which we often treat the vanquished enemy with greater courtesy, than those, whose quarrel we undertook. Discourses against vices may be as well indited by vanity, as by zeal, and meant to express wit, not persuade piety. And if (as it chanced but too frequently) we grow proud of them, we do, like witches turning exorcists, only comply with Satan to cast out the devil.

EUSEB. To second your pious reflection, *Lindamor*, with some thoughts suitable to my profession, I will add, that in the case you put, it happens to us as it once did to *Gideon*, who, of the spoils of God and *Israel's* conquered enemies, made an idol, which proved, in the end, his, and his house's snare. It was a most instructive check, and divine admonition, that our Saviour gave his Apostles, when, in the account they brought him of their embassy, they joyfully related their exercised power, of dispossessing devils; notwithstanding (answered Christ) in this rejoice not, that spirits are subject to you, but rather rejoice, that your names are written in heaven. In effect, though *Judas* were one of the persons, invested with this miraculous power of casting devils out of others, yet we read, that *Satan* afterwards entered into *Judas*, and that it had been good for him, that he had never been born. And though, as *Solomon* tells us, he that winneth souls, is wise, yet it is he only, that shall do, as well as teach, the commandments, that shall be called great in the kingdom of heaven. And the judge himself informing us that, at the world's last day, many will plead their having in his name not only prophesied or preached, but cast out devils, and shall yet be disclaimed by him, sufficiently intimates, that it is as possible, as unavailable, to do many wonderful works (for religion) and to be workers of iniquity. The true Christian should, *Lindamor*, be willing to impart any useful discoveries, that God shall please to vouchsafe him; but he will ever consider the takingest notions he can frame of virtue, more as engagements to it, than arguments of it: and since there is not any thing, in which charity ought more to begin at home, than in devout instructions, he will

Judg. viii.
24, 25,
26, &c.

Mat. v. 19.
Mat. vii.
22, 23.

Luke vi.
45.

1 Cor. ix.
27.

endeavour to make himself as much piety's votary, as advocate; to imitate those truly wise men, that, as they informed those of *Jerusalem* of the star they had seen in the east, did themselves follow it, till it brought them unto Christ; to entitle himself to that of our Saviour, *a good man out of the good treasure of his heart, brings forth good things*: and (finally) to take his celebrations of virtue from his experience, not his fancy; as nurses first feed themselves, to nourish their sucking infants, to whom they give no meat, which they have not in their own breasts first digested into milk, lest (like the carpenters, that toiled to build the ark to save *Noah* from the deluge, themselves perished in) *when he has preached to others, he himself should prove a cast-away*.

A continuation of the discourse.

GENOR. **S**URE, gentlemen, it is a happy thing to be able to convert the meanest things to the noblest uses, and make whatever one pleases subservient to piety, by skilfully imploing even slight and unpromising occasions, to represent her, with the advantages of a varied and surprizing dress, whereby you may procure that virtue lovers, and your selves friends: for her votaries are so ingenuous and disinterested in their amours, that they have as well a kindness for their rivals, as their mistresses.

LIND. I will not deny, but that there may be persons so inflamed with heavenly love, that their devotion is able, like the last fire, that is to refine or destroy the world, to turn all things into fuel for its victorious flames; and who, when they are once engaged in meditation, can make their pious thoughts excite themselves and flame up higher, and higher, without the assistance of other incentives, than what their own fervency procures them; as it is observed, that when the fire has seized upon a town, by how small a spark soever it have been kindled, if the flame come to be very great, though the air be very calm, the fire it self will produce a wind, that without the help of bellows shall strongly blow it, and make it blaze the more, and aspire towards heaven. But, *Genorio*, whenever (for I answer but for my self) I shall meet with any such happy contemplators, I shall have the justice to be one of their admirers, without having the vanity to pretend to be one of their number.

EUSEB. And I, for my part, shall tell you, *Genorio*, that though there may be divers charitable persons, besides your self, that by the expressions it becomes me to use in some of my meditations, and other composures of the like nature, may be apt to fancy that I am my self as devout as I endeavour to make my readers, yet you must not imagine that my mind, like one of those writings, has no other thoughts than religious, or at least moral ones; for those may be the productions, not of a constant frame of mind, but of occasional fits of devotion: and you may read a greater number of such reflections in an hour than, perhaps, I have made in a month, not to say in a year. And I must ingenuously confess to you, that I think it more easy to make ten good sermons than to practise one, and to declaim against all sins than to relinquish any: there goes much less self-denial to conform to the precepts of *Cicero*, than to those of Christ; and I find it so much less difficult to excite other men's passions, than to command my own, that if you will not suffer your charity too much to injure your judgment, you must look upon the devouter passages you may have met with among my composures, as expressions of what I aim at, rather than of what I practise.

*An Account of a very odd monstrous Calf; printed first in the
Philosophical Transactions, N^o I. p. 10. Anno 1665.*

BY the same noble person [Mr. Boyle] was lately communicated to the Royal Society an account of a very odd monstrous birth, produced at *Limmington* in *Hampshire*, where a butcher, having cauled a cow (which cast her calf the year before) to be covered, that she might the sooner be fatted, killed her when fat, and opening the womb, which he found heavy to admiration, saw in it a calf, which had begun to have hair, whose hinder legs had no joints, and whose tongue was, *Cerberus*-like, triple, to each side of his mouth one, and one in the midst: between the fore-legs and the hinder-legs was a great stone, on which the calf rid: the sternum, or that of the breast, where the ribs lie, was also perfect stone; and the stone, on which it rid, weighed twenty pounds and a half: the outside of the stone was of a greenish colour, but some small parts being broken off, it appeared a perfect free stone. The stone, according to the letter of Mr. *David Thomas*, who sent this account to Mr. *Boyle*, is with Doctor *Haughteyn* of *Salisbury*, to whom he also referred for further information.

An Observation imparted to the noble Mr. Boyle, by Mr. David Thomas, touching some particulars further considerable in the Monster, mentioned above; printed first in the Philosophical Transactions, N^o II. p. 20.

UPON the strictest inquiry, I find by one, that saw the monstrous calf and stone, within four hours after it was cut out of the cow's belly, that the breast of the calf was not stony (as I wrote) but that the skin of the breast and between the legs of the neck (which parts lay on the smaller end of the stone) was very much thicker, than on any other part; and that the feet of the calf were so parted, as to be like the claws of a dog. The stone I have since seen; it is bigger at one end than the other; of no plain superficies, but full of little cavities. The stone, when broken, is full of small pebble-stones of an oval figure: its colour is grey like free-stone, but intermixt with veins of yellow and black. A part of it I have begged of Dr. *Haughteyn* for you, which I have sent to *Oxford*, whither a more exact account will be conveyed by the same person.

NEW
 EXPERIMENTS
 AND
 OBSERVATIONS
 TOUCHING
 COLD:

OR,

An Experimental History of COLD begun.

To which are added,

An EXAMEN of *ANTIPERISTASIS*, and
 An EXAMEN of Mr. *HOBBS*'s Doctrine about COLD.

Whereunto is annexed an ACCOUNT of FREEZING, brought into
 The ROYAL SOCIETY by the learned Dr. *C. MERRET*, a Fellow of it.

Together with an APPENDIX, containing some promiscuous EXPERIMENTS
 and OBSERVATIONS relating to the precedent History of COLD.

Non fingendum, aut excogitandum, sed inveniendum, quid natura faciat, aut ferat. BACON.

The Publisher to the Reader.

A GREAT progress having been made at the press in the second edition of the *History of Cold*, before the author was acquainted with it, he did not think fit to make any alteration of the former edition, but left it to come forth this year, just as it was printed seventeen years ago, *viz.* in the year 1665.

For the same reason, the author declined making any alteration in the introductory preface; whose prolixity seemed very excusable, because it was not barely a preface to the particular book, whereunto it was prefixed, but (as the title was designed to intimate) contained divers considerations introductory to the *History of Cold* in general, and superadded divers experiments and observations to those, that were delivered in the history itself.

THE author thinks he may justly hope, that equitable readers will not look upon the thermometrical discourses, that are premised to the *History of Cold*, as unfit to appear again with it; though some of the particulars, that are there delivered as paradoxal,

doxal, are now acknowledged for truths by most of the Virtuosi; and others, that are proposed as new observations and practices, are, at present, come into common use among the curious. For the ancient date of these discourses will easily make it appear, that the things they mainly consisted of, were then novelties. And he hopes it will not disparage them among the equitable readers, that many have since thought fit to embrace the opinions, and make use of the practices there proposed.

BUT it will be now expected, that somewhat should be said about the following Appendix, wherein the author is very sensible, that he stands more in need of the reader's equity and favour. For, not being solicited to make a second edition, (after men's curiosity and the fire of *London* had dispersed or destroyed the first) till want of leisure made him unwilling, and want of health almost unable, to revise and prosecute that work; he threw aside the particulars he intended to add among other loose papers, where for many years they lay neglected, and probably there were divers of them lost: so that when the stationer and several other persons were pressing to have a new edition of the former *History of Cold*, and gave the author notice, that a good part of it was already printed off, and waited for some additions, that they earnestly desired, he had much ado to retrieve any considerable number of notes; most of which too being occasionally written, when he could not get one exemplar to collate them with, (the stationer himself having not so much as one book left) it was almost necessary, that many of them should be so written, as to be easily and smoothly joined to the titles of the formerly published history. So that the author (who at that time was much indisposed) having neither health nor leisure to put this chaos of loose memoirs into some order, desired a learned friend to take upon him the trouble of doing it for him: yet it was not possible, for all that ingenious person's care and diligence, to give a good method and smooth connexion to so confused an heap of particulars; all that the difficulty of the attempt permitted him to do, being to refer the particulars, as near as might be, to the respective titles they seemed most to belong to.

It remains, that the reader be told, whence the materials have been taken, whereof the following Appendix doth consist: some few of them have been drawn out of printed books, because cold (in itself, a subject barren enough) has been left so uncultivated by classic authors, that, according to our judicious *Verulam's* advice, it was not thought fit to cast away any credibly-related matter of fact, that might add to the history of it. But the greater number by far of the following particulars was taken from the relations of navigators and travellers, whom the author had the curiosity to consult about the phenomena of cold, they had met with. And for the better gaining of such informations, he became an adventurer in that, which is commonly called the *Company of Hudson's Bay*; to which those that are from time to time sent from *London*, do, either in their voyages thither and back again, or in their stay in that frozen country, not unfrequently meet with considerable, though unwelcome effects of cold. But two persons there are above the rest, from whose answers the author drew the considerablest part of the following Appendix. One was an ingenious English physician, dead many years since, that was archiater to the then Russian emperor; for whom our author having furnished this physician with some pleasing, and yet effectual, chymical medicines, that were very well liked, and nobly rewarded by the Czar, the author desired, as his recompense, to have some observations about cold (whereof he sent a list) made in *Russia*, and especially at the city of *Moscow*, where the physician, attending his master, resided. The answers to Mr. Boyle's queries were, by misfortune, not sent by themselves, but in several letters intermingled with so many other passages, relating to the Russian monarch's government, religion, &c. that to put them in the writer's own words (which was thought
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the fairest and surest way to prevent mistakes) some of them must be dismembered from the context, and so must appear as torn and incoherent rags, and consequently to the great disadvantage of the papers they are made parts of. The other principal informations to be met with in this Appendix, the author received in divers conferences he procured with an ancient sea-captain, who was looked upon as the greatest navigator into the Northern seas, that has been known; upon which account his majesty himself had the curiosity to send for him, and discourse with him. This lusty old man had made above thirty several voyages into the frigid zone; and being then (as he still is, if he be yet alive) in the service of the company of *Hudson's Bay*, was, upon that account, the more willing, and the more free, to make answer to the author's questions, even when it required the discovery of his most secret observations. And, that this preface may not be altogether useless to the design of the history it belongs to, I shall add, on this occasion, that the author having been visited by the principal person, that ventured to winter in *Hudson's Bay* (where the ingenious captain *James*, often mentioned in the foregoing history, found it almost, if not quite, as rigorously cold, as the Hollanders found *Nova Zembla*) he was particularly inquisitive to learn of this person, how he was able to support the extreme rigours of the cold all the winter long: to which inquiry the navigator answered, that the cold was scarce sufferable the first year he settled there; but that afterwards they had found an expedient to make their wintering not only tolerable, but comfortable enough. And being pressed to name this expedient, he ingenuously confessed it to be this; that they dug so deep into the earth, where they thought fit to erect their wintering-house, that about one half of their mansion, and that part, wherein they dwelt themselves, was built under ground; by which means the cold air could not laterally pierce into it, so that they slept warm enough, and in the day-time could keep themselves from excessive cold, as long as they continued in that subterranean part of their house.

THE following papers having been sent away to the press, without being reviewed by the author after the particulars, that compose this Appendix, were ranged in the order they now appear in; when afterwards he received them all at once as they now stand printed, he found (not without being troubled at it) that to comply with the design of referring particulars to their proper heads, some passages in this new model of them had lost their dependencies, or the connexions they had in the papers whence they were taken. As for instance, the governour of *Smolensco*, upon the borders of *Poland* and *Russia*, though not here called by his own name, is mentioned as a person formerly nominated; which might well be done in the papers, whence this particular was extracted, because he had in them, before that, been quoted by the name of Lieutenant-General *Drummond*. Nor is this (it is feared) the only passage, wherein the almost necessary dislocation of particulars, that before had a manifest connexion, may need the reader's pardon, which is therefore begged by the author; who yet hopes, that these passages will not be found numerous, and that an attentive reader will, by circumstances, easily enough discern what things are his own, and those comparatively few, that might have been more expressly delivered, as received from others. This inconvenience was not espied, till it was too late to prevent it.

SOME few particulars in the following Appendix may perhaps be found coincident, as to the main, with some passages of the book it is annexed to, and yet differing in some circumstances. But these the author thought it candid not to suppress, because in historical matters truth is the thing, that is to be principally regarded: besides, that in these points, wherein the relations of the history and of the Appendix agree, they will mutually confirm each other, (which in matters, whereof few trials or observations are yet extant, is a thing of no small moment) and those circumstances, that

that may suggest limitations or cautions, may be of good use in the *Philosophick History of Cold*, and engage the curious to make a farther search by heedful and repeated trials.

THE author had divers other papers, that might have enriched the present Appendix, if the confusion, that was occasioned among his manuscripts, by a sudden fire, that obliged him very hastily to remove them after midnight, had not suppressed them, (and which he hath elsewhere complained of, as very prejudicial to him in reference to other tracts) at least till another opportunity. But without the prospect of a larger appendix, the printer wanted not encouragement to press for a second edition, by the favourable reception, that was given to the first by divers learned men, not only at home but abroad: where Monsieur Du Hamel, famous for many curious and elaborate pieces, in one of his learned treatises, gives this character of the foregoing history: *Cum anno superiore inciderim in librum de frigoris historia, ab illustri & doctissimo viro D. Boyle compositum, quo argumentum, à philosophis penè intactum, tam diligenter & eruditè pertraxerat, ut vix quicquam accuratius sperari possit. Du Hamel Corp. Aff. Cap. de Frigere.* And since him an ingenious doctor of physick, (that in a cold climate has written, though not copiously, yet learnedly and *ex professo*, of cold) speaks thus of our author and of his history: *Agmen hoc eruditum* (having spoken before of the chief authors, that have written about cold) *claudat Dominus Boyle, delictum & ornamentum nostri temporis, cui jam nunc omnem nostram attentionem renovare æquum est. Non enim aliam ob causam hoc loco ultimo eum amplectendum nobis servavi, quàm ut veluti per compendium, liberiori tamen paulò excursionem factâ, & seposito nonnihil capitum præcedentium ordine, tum ea, quæ jam partim allata fuere, tum quæ dicenda adhuc restant, sine tædio & concinnâ brevitate, ejus quasi ductu, quem toto hoc lubrico & glaciali itinere ducem mihi proposui, examini ulteriori subjicerem.* Conradi Dissertat. Medico-phys. de Frigoris Natura & Effectibus, page 51.

THESE just eulogies of our honourable author (to omit many others) are here inserted, not to grate on his modesty by the repetition of his own (tho' merited) praise, but as incitements to the studious to peruse his philosophy, with the principles thereof, contained in this and his other tracts, (which in many things differ from those of the *Peripatus*, the *Academia*, and the *Stoa* too) in regard they have already passed the test of the learned both at home, and also beyond the seas. For though, as an ingenious writer speaks in another case, little heed is to be given to the gale of a private man's fancy, yet it is considerable, when the wind blows from all quarters. The universal approbation, which the labours of our author have met with, requires an high veneration for, and medullary search into, his writings. It was the saying of an ancient rhetor, in reference to oratory, *Ille se multum profecisse sciat, cui Cicero valde placuerit*; which may be applied with as much veracity to Mr. Boyle, whose philosophical lucubrations about the subjects he is pleased to ventilate and discuss, are the top of their kind. Therein the *Initiati* may find great encouragement for their progression, and also those, who are more experienced, and sit but one form below the *Adepti*, may count it no disparagement to learn of him, whose disquisitions have been so instructive to the learned world.

An ADVERTISEMENT.

THAT the reader may not wonder to find the following dialogue cited in the *History of Cold*, whereunto nevertheless it is subjoined; he is to be informed, that a section about *Antiperistasis* was really both written and transcribed before any part of that history was sent to the press. But finding, that the accession of new particulars had so much swelled it, that it was unfit to pass (as I first designed it should) for one of the titles of the *History of Cold*, I judged it convenient to sever it from the rest, upon the score of its bulk, and yet annex it to them upon the account of those many historical passages in it, that belong to the same subject, that is handled in those sections. The reader will quickly find, that the tract consists of two parts, whereof the first (which to allow the more freedom of inquiry and discourse, is written in the way of dialogue) contains an *Examen* of *Antiperistasis*, without pretending to question it absolutely and indefinitely, but rather, as it is wont to be taught and proved. And this dialogue, for reasons, that it too little concerns the reader to know, and would take up too much time to tell him, both begins as a continuation of some former discourse, and somewhere mentions the author, as a third or absent person. And to make it the more like to other dialogues, the quotations are not made with the author's punctualness in the rest of this book, but yet with his usual faithfulness; nor hath his introducing men discoursing (as it were by chance) kept him from putting into the margin the very words of some passages, which he thought the most important and likely to be distrusted. But though this first part be entire and finished in its kind, and so might very well (if not best) have been put forth single, to invalidate the common doctrine of *Antiperistasis*, (in the sense wherein it is there opposed) yet because in philosophical matters, it is not so much victory or applause, that is to be sought, as truth; I forbore not to subjoin to a discourse, that may perchance satisfy most of my readers, some scruples, about which I wished for further satisfaction and certainty my self; of the chiefest of which, the sceptical consideration will give the reader an account.

The Publisher to the ingenious Reader.

IAM fully persuaded, you will much rejoice to see that exquisite searcher of nature, the illustrious *Robert Boyle*, come abroad again, as knowing he never does so, but when richly furnished with very instructive and useful matter. He presents you here with a treatise of *New Observations and Experiments, in order to an Experimental History of Cold*. This is the body of the book; but it comes accompanied with some Preliminaries, and an Appendix, whereof the former contains *New Thermometrical Experiments and Thoughts*, the latter an *Exercitation* about the *Doctrine of Antiperistasis*, followed with a short *Examen* of *Mr. Hobbes's Doctrine, touching Cold*. From all which it will more and more become manifest, with what spirit and care this excellent person advanceth real philosophy; with what exactness he pursueth his engagement therein; and how great caution he useth, that nothing may slide into the philosophical store, that may prove prejudicial to the axioms and theories hereafter perhaps to be deduced from thence.

H A V I N G

HAVING thus shortly given you my sense of the substance of this considerable treatise, I am now to advertise you of one or two circumstances, necessary to be taken notice of in its perusal.

ONE is, that the noble author being at *Oxford*, when the book was printed at *London*, he hopes the reader will not impute to him the errors of the press, which yet he is persuaded will not be many, and out of which must be excepted a blank or two, occasioned by this, that the author's papers being near two years since given to be transcribed to one, whose skill in writing was much greater, than (as it afterwards appeared) his knowledge of what was, or was not good sense, or true English; this person suddenly going for *Africk* before the transcript had been examined, and not taking care to leave all the first copy, the author found, (besides several blanks, that he filled up out of his memory, or by repeating the experiments, they belonged to) one or two, where he was not able to repair the copist's omissions: and besides unexpectedly met with very many passages so miserably handled, that by putting him to the trouble of writing almost a new book, when part of this was already in the press, it much retarded the publication of that, which now comes forth.

THE other is, that, whereas in the preface some passages are so penned, as to suppose the book to be published early in the winter, the reader is to be advertised, that the former part of this preface was sent a good while since to the press, though the latter, however then written out, was hindered from accompanying it, by some hopes of the author's to gain by delay an opportunity (he missed of) to perfect an experiment he was desirous to insert; and that, when the frost began, which was late in the season, the coldness did within a while arrive at that degree, that by its operation upon the moistened paper, it long put a stop to the proceedings of the press. But the author, that he might neither be quite defeated of his aim, nor disappoint the curious of their expectation, did in the first or second week of the frost, which was about the end of the year 1664, present the Royal Society with divers copies of the *History of Cold*, though the book were not then quite printed off. And these books being so near finished, that of twenty-one sections, whereof the *History of Cold* consists, the press had then reached to about the 19th, and I had the 20th in my hands to supply it, when the weather should permit; the author hoped, that by seasonably communicating so much of his intended treatise to so many of the Virtuosi, that were the likeliest to make use of it, he had pretty well provided against the prejudice, that might otherwise accrue from the slowness of the press, and therefore allowed himself to subjoin to the history, the discourse of *Antiperistasis*, and the *Examen* of Mr. *Hobbes's* doctrine*, as belonging to the same subject. And finding the frosty weather to continue later than was expected, (which had he foreseen, before his history was printed off, it would have given him opportunity of enlargements) he hopes the publication may not be yet too late for diligent readers, to make some use of the season for examining his experiments, or trying some of the new ones, those may suggest. And therefore for the quicker dispatch of the book, he purposely omits, and reserves for another occasion, besides the papers, that he hath not yet given me, some that I have already in my hands. And it is, I presume, for the same reason, that he forbears to publish, what he long since writ about the origin of forms and qualities, in a small tract, which he had thoughts of sending forth in the company of the ensuing history, as a discourse fit to be an introduction as well to that, as to his historical writings about colour and some other qualities.

* It was thought needless to insert Mr. *Hobbes's* scheme touching this subject, because it only shews, that wind is the cause of cold.

The Author's Preface.

THIS is all the advertisement I had to give you. And seeing it would be altogether impertinent, for me to take any pains, or to use any art to procure a gift for a book, composed by Mr. Boyle, I have no more to say, but that the author being so generous as to oblige foreign nations as well as his own, has already taken care of having it put into Latin. Farewel.

London, March
10, 1664-5.

H. O.

The Author's Preface Introductory.

COLD is so barren a subject, and affords so few experiments, that are either very delightful for their surprising prettiness, or very considerable for their immediate use, that instead of admiring, that any of my friends should wonder at my having been induced to write of such a theme, I freely confess, that I have been sometimes tempted to wonder at it my self; and therefore I think my self obliged to give my readers an account of these three things; Why I thought fit to write of cold at all? For what reasons I have treated of it after the manner to be met with in the ensuing book? and, Why I venture my unfinished collections about it, abroad so soon?

I. To satisfy the first of these queries, I have several of these things to say.

AND first, that the subject I have chosen is very noble, and important; for since heat has so general an interest in the productions of nature's phenomena, that (motion excepted, of which it is a kind) there is scarce any thing in nature, whose efficacy is so great, and so diffused, it seems not likely, that its antagonist, cold, should be a despicable quality. And certainly cold, and heat, especially when employed by turns, are the two grand instruments, by which nature performs so many of her operations here below, that our great *Verulam* did not speak inconsiderately, when he called heat the right hand of nature, and cold her left: and though in our temperate climate the effects of cold seem not to be very remarkable, yet besides that in more northern regions they are oftentimes stupendous, the nature of that quality must needs be very well worth our considering, if it were but for the power it has to moderate and check the operations of heat; upon which account alone, if there were no other, it may be looked upon as so considerable a quality, that even lesser discoveries about it may both be acceptable and prove useful.

IN the next place I shall represent, that notwithstanding cold's being so important a subject, it has hitherto been almost totally neglected. For I remember not, that any of the *Classick* authors, I am acquainted with, have said any thing of it, that is considerable. They do indeed generally treat of it, as one of the four first qualities. But that, which they are wont to say, amounts to little more, than that it is a quality, that does congregate both things of like and unlike nature; the unsatisfactoriness of which vulgar definition I had some years ago an occasion to manifest (in another treatise, the *Sceptical Chymist*): and having given us this inconsiderate description of cold, they commonly take leave of the subject, as if it deserved no further handling, than could be afforded it in a few lines, wherein indeed they say too much about it, but not enough. And even among other writers of bodies of natural philosophy, or of the doctrine of meteors itself, the reader will find, how little of true and pertinent has been contributed to the ensuing *History of Cold*. And though among the vulgar,

and the writers, that adopt their traditions without examining them, I find some few particulars delivered touching cold; yet some of them are so untrue, and others so uncertain, that they have furnished me with little else, than the necessity of questioning, or of disproving them: so that when I considered all these things, I could not but take notice, that very little hath hitherto been said of cold, by those schoolmen, and other writers, (that I have yet met with) who have professedly (though but perfunctorily, and, as it were, incidentally) treated of it. But yet instead of thinking it a discouragement, that so many learned men, to whom that quality could not but be obvious, and to whom it was as familiar as to me, had in so many ages said little or nothing of it to the purpose; I found this very thing an invitation to my attempt, that I might in some measure repair the omissions of mankind's curiosity towards a subject so considerable, and so diffused, by trying what I could do toward founding the history of a quality, which has been hitherto so neglected, as if all men judged it either unworthy of being cultivated, or incapable to be improved.

ANOTHER inducement to me was, that having six or seven years ago written some tracts (though I have not since had opportunity to publish them) in order to the History of *Heat and Flame*; it seemed the more proper for me to treat of the contrary quality, *Cold*; since, according to the known rule, confronted opposites give themselves a mutual illustration. And another inducement of almost the same nature was afforded me by remembering, that whereas cold, in its higher degrees, is wont to be communicated to us by the air (whencesoever the air has it) and I have on several occasions been obliged to treat of divers properties of the air, as of its weight and spring (in my *Physico-Mechanical Treatise*) of the several strengths of that spring, in proportion to the degrees of the air's condensation; the experiments of which, reduced into tables, were first published (and for aught I yet know made) by us, (in the defence of that book against *Franciscus Linus*, chapter the fifth of that treatise) and of divers other qualities of the air in several passages of our other writings, which it were now superfluous to take notice of; all this made it appear convenient enough, that among other attributes of the air, which we either have had, or expect to have occasion to treat of, so eminent and diffused a one as its coldness should not be left untouched by the same pen.

BUT though neither any, nor all these inducements had been sufficient to engage me to draw together, and recruit my observations concerning cold, there was another, that could not miss of prevailing, the command of the Royal Society, imposed on me in such a way, that I thought, it would less misbecome me to obey it unskilfully, than not at all. Especially since from so illustrious a company (where I have the happiness not to be hated) I may in my endeavours to obey and serve them, hope to find my failings both pardoned, and made occasions of discovering the truths, I aimed at.

II. AFTER this account of the motives, that induced me to resolve to draw together the notes I had on several occasions set down, about the phenomena of cold, it may be now expected, that I render some reason, why I have thus digested them, and why I have not written the following treatise in a more accurate way.

FIRST, then I readily acknowledge, that the method is not exact. Nay, that it is less so than the scheme of heads of inquiry, that I drew up, to give myself a general prospect of the subject I was to handle. But when I had considered, how comprehensive a theme I had pitched upon, and how much more comprehensive, future discoveries and hints might make it, I thought it altogether unadvisable for me, that
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had no more time, nor no more opportunity than I had, when I begun to compile the following history, to engage my self to a method, according to which I was not perhaps able to treat of any one of the principal parts of the designed history. And yet, on the other side, being unwilling to huddle my experiments confusedly together, I thought it an expedient, that might in great part decline both those inconveniencies, to draw up a company of comprehensive titles, under which might commodiously be ranged most of the particulars I had observed, reserving those few, that were not so easily referrible to any of those, to be thrown at last into a section by themselves. And this I the rather did, because I would not, by a confinement to a strict method, discourage others from continuing the history, by adding new titles to those twenty-one, I have treated of, as well as by inserting other experiments or observations in any of them.

THAT the sections or titles are very unequal, will not, I presume, be much blamed by them, that consider, that my design being to set down matters of fact, not write a complete and regular treatise, the length of each section was to be determined, not by its proportion to that which went before it, or followed after it, but by the number and condition of the particulars, that were to compose it. And I thought it much more pardonable, that any of the sections should be disproportionately short, than lengthened either by untruths or by impertinencies.

SOME of the accounts will probably to some readers appear too prolix; and I could very easily, as well as willingly, have prevented that objection, if I had not more consulted the scope of the book, than the ease or reputation of the writer. But my design being, not only to gratify some readers, but to assist others to prosecute the work I had begun, as the experiments are most of them new, and many of them tried by methods hitherto unpractised; I conceived my self obliged to set down somewhat circumstantially, not only the events, but the manner of my trials, that I might at once, both the better satisfy the scrupulous, and be assistant to those, that would examine or repeat such experiments, and also gratify those, who are pleased to think, that a somewhat assiduous conversation with nature may have given me some little faculty in devising experiments, and the ways of making them, above those, that have been conversant only with books and notions. And in some of the following trials I was the more induced to set down all the principal circumstances, because that being not to be made, but by the help of glasses skilfully shaped, and hermetically sealed, and other instruments and operations, that require more tools, and more of manual dexterity, than every ingenious man is master of; it is very likely, that most readers will not be able, or perhaps willing, to reiterate such trials, and therefore will be glad to find them so delivered, as that they may without too much danger acquiesce in them, as being made with diligence as well as faithfulness. The latter of which qualities will, I presume, be allowed me, as well upon the account of the plain and simple way, wherein matters of fact are delivered in the following book, as upon the score of the testimonies, that even adversaries, as well as others, have thought fit to give to the historical part of my former treatises. And (to intimate that on this occasion) this strict fidelity to truth I scruple not to own, though perhaps it may be attended with an inconvenience in point of reputation, that writers of less veracity are exposed to. For I have found by experience, that some men, who probably would not mention the experiments of most others, without vouching their authors, for fear of losing their own credit, in case the thing related should not prove true, have, without taking the least notice of me, made use of such experiments of mine, as I have strong motives to think they never made nor saw, only because they had been related by one, after whom they thought they might without a hazard of
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their credit deliver any matter of fact. And the liberty, that some have allowed themselves in adopting my communications (such as they are) is notorious enough to have been publickly complained of more than once, by persons, that are meer strangers to me. But though I had not the probability, which the notice, that begins to be taken of it, seems to give me, of having some justice done me; yet veracity is a quality, that does, I think, so well become a Christian and a writer of natural history, that I had much rather undergo any disadvantage, I may be subject to for it, than decline the practice of it. But to return to the following history.

I CONFESS the prolixity of some passages of our history is increased by the transitions, excuses, and suspicions, that are made use of in them; but I confess too, that if this way of writing be a fault, it was not always caused by inadvertency. For as to what is said to connect the parts of our history together, or excuse the not prosecuting of this or that particular trial, the heedful reader may oftentimes perceive, that they contain in them, though not perhaps conspicuously, either cautions, or advertisements, or hints, not impertinent to my main scope, and improveable by an attentive peruser. And as for the suspicions and scruples, to which now and then I may seem to have too long indulged, I had two or three inducements to invite me to what I did. For the mention of conjectures, that every reader was not so likely to light upon, might more conduce, than at first one would think, to the main design of my book, which was to begin, and promote the natural history of cold; since these suspicions about the causes and scruples about other things, relating to our experiments, may probably produce, not only new reasonings and inquiries, but new trials, to clear the difficulties, and determine the doubts. Besides, I thought it not amiss to take such occasions to make some readers sensible, that to make indubitable inferences even from certain experiments is not near so easy a work, as many are pleased to imagine. And whereas I was not without inducements to think, that some critical and sagacious readers will not only excuse my having taken notice of so many scruples, but wish I had moved more on some occasions, and proposed some in certain cases, where I have not mentioned any, I thought it might invite such jealous readers to think, that I foresaw divers little difficulties and scruples, that might be moved in several cases, where I have not expressly taken notice of them, either because I judged them easy enough to be answered without my help, or because the things themselves were not considerable enough to deserve a long or solicitous discourse to clear them, especially from a writer, that being often tired himself in examining such niceties, was afraid he should too much tire the generality of his readers, if he should too frequently insist upon them.

If it be objected, that notwithstanding some things are set down prolixly, yet other experiments, that might properly be referred to some of the titles I handle, are wholly omitted; I answer, that this were indeed a fault in one, that should pretend to write full and accurate discourses of the subjects proposed in his titles, but not in me; who do not at all pretend to say, under each head, all that may be pertinently referred to it, (for that may probably be a great deal more, than is yet come to my knowledge) but only those particulars, that I myself have tried or observed, or at least have received upon credible testimony. And, perhaps, some amends may be made for these omissions, by my having frequently enough mentioned the experiments, that, when I proposed them, I had only designed or attempted without perfecting them. For the experience of many ages has shewn us, that hitherto, not only men do not appear to have made any store of trials concerning cold, but seem not to have so much as designed it. And therefore it seemed not unreasonable to presume, that it would

would prove an assistance to the generality of readers, if probable and practicable experiments were proposed to them. And since it is the improvement of the subject that I aim at, by whomsoever it may happen to be improved, I thought it but reasonable to use my endeavour, that those experiments, which for want of opportunity I myself could not try, might be tried by others, who may be befriended by more favourable circumstances. Nor is that great ornament and guide of philosophical historians of nature, the Lord *Verulam* himself, ashamed to substitute, on I know not how many occasions, his *fiat experimentum*; that is, a precept or a wish to have an experiment made, instead of an account of the experiment made already. And yet in this mention of things, I could wish to have tried, I have been far more sparing than every reader will take notice of. For I judged it not discreet to mention all the experiments I had thought upon, or even already set down in several catalogues, lest they should appear extravagant to those, that are unacquainted with the several notions, and trials, and contrivances, which made them appear to me not irrational, and which yet it would have been tedious, and not worth while to have particularly mentioned.

BUT that in what we have newly (and a little before) had occasion to say of our ways of making experiments, our meaning may not be misconstrued, we must here advertise the reader, that though, in many of the following experiments, the contrivances will not, perchance, be disliked, yet in many others, they are far enough from being such, as might have been proposed by one, that had wanted no accommodations fit for such a work as ours. But I was reduced to make many of those experiments in a village; and whilst I was writing them, was obliged to make frequent removes, by which means I seldom had the liberty to make my trials after such a manner, as I could contrive them, if I could have instruments and other assistance to my wish. For sometimes I wanted conveniently-shaped glasses; sometimes the implements necessary to seal them up with; sometimes such ingredients, as I needed to work on; oftentimes frosty weather, for the freezing of bodies to be exposed to the open air, and not seldom ice and snow for artificial congelations; sometimes weather-glasses, especially sealed ones, two of which being unluckily broken after one another, kept me from being able to make divers considerable experiments; sometimes tender scales, and sometimes other mechanical instruments of several sorts, and more than sometimes (for it happened very frequently) I wanted time so to prosecute and finish the experiments, as to satisfy myself about divers circumstances, which, though possibly few readers will take notice to be wanting, I would gladly have observed, if I had not been hindered, not only by the haste I was often fain to make for fear of losing a frost, but the importunities both of other avocations, and even of the distraction given me by the multitude of experiments, which haste made me prosecute at once. And indeed, as in divers others of the treatises, I have occasionally written, so particularly in a great part of this *History of Cold*, my writing in places, where I wanted such mechanical accommodations, as I could have wished for, and devised, has reduced me oftentimes both to leave experiments untried, that would have much illustrated my subject, or cleared the difficulties of it, and contrive several of those I mention, not after the best manner that might be, but after the best manner, that was practicable by the accommodations I was then able to procure: so that it need not be wondered at, or blamed, if in some passages of these papers, experiments to the self-same purpose are more accurately tried, or by more expedient ways at one time than another. For as a physician, if he come to practise in the country, where apothecaries shops are but ill furnished, both as to the number and as to the quality of the drugs, must accom-

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moderate his practice to the scant *materia medica*, of which alone he has the command: so when I write of experimental matters, in places where I cannot have workmen, nor instruments fit for my turn, I must be content to vary my experiments accordingly, and suit them to the accommodations I am confined to; which, though it be an unwelcome condition, is made the less so to me, by a hope, that the equitable readers will think it to be all, that a man is bound to do in such cases, to procure the best assistances he can, and manage those, he is able to procure, to the best advantage.

AND this I rather take notice of on this occasion, that ingenious men might not be too much discouraged by imagining, that, because they live in the country, or upon other scores, cannot furnish themselves with the best instruments and accommodations, nor enjoy the assistance of the skilfullest artificers, they are either unqualified for the making of experiments and observations, or superseded from it. For though, in some cases, where the measures of things must be nicely determined, and principally in observations, whereon either theorems or hypotheses about the proportions of things are to be grounded, very good instruments are exceeding useful, and sometimes necessary; yet there are thousands of particulars, whose knowledge may be instructive to those, that are or would be Naturalists, where no such nicety is requisite, and where the measuring things by ounces and inches will serve the turn, without determining them to lines, and grains. And even in cases, where exact observations are (to some purposes) requisite, those, that are not so, may be oftentimes very useful, by affording hints, by which others may be excited and assisted to make those more accurate trials. And here let me take notice, that a tool or instrument is not therefore to be despised, if it be proper enough to the particular use, to which it is applied, because some more mechanical head or hand may propose or make another, that is more artificially contrived, or more neat and portable, or that will also perform other things, than that we are speaking of. For there is a vast multitude of physical phenomena, wherein mathematical exactness is not necessary, and observations about these may be well enough made by divers other ways, than by the most artificial, that can be devised. As though a fine watch may have these advantages, that it is a neater thing, and more portable than an ordinary clock; that it may be improved by the addition of an alarum, and that it may also, perhaps, shew the day of the month, the age of the moon, the tides, and divers other things, of which the clock shews not any: yet an ordinary clock may serve to measure an hour by, as well as this finer engine; and so may a sun-dial, and many other instruments on divers occasions; though in other cases, and other regards, they be far less commodious, than either a watch or clock. Besides, that in many cases a skilful Naturalist will, by a variety and collation of experiments, make the same discoveries, and perform the same things, for which others be wont to be beholden to instruments, and perhaps do many things without them, that have never been done with them. And since necessity is proverbially allowed to be the mother of inventions, even in tradesmen, and vulgar heads, why should we doubt, but that the rich and inventive intellect of a philosopher may, in cases of necessity, turn itself, and contrive the things it can dispose of, into so many differing forms, that it will often make its own sagacity and industry supply the want of exact tools and instruments? And these considerations, that tend to keep ingenious men from despondency, I therefore think fit to inculcate, because the commonwealth of learning would lose too many useful observations and experiments, and the history of nature would make too slow a progress, if it were presumed, that none but geometers and mechanicians should employ themselves about writing any part of that history.

BUT to return to those trials of our own, that occasioned this (as I hope, seasonable) digression, I was about to add, that as the acknowledgment I was making, that some of the trials were, for want of accommodations, less artificial than I could have designed or wished them, touches not all, nor haply the greatest part of the following experiments; so it need not derogate from the readers reliance on those, which it does concern. For though some of them might have been more artificially performed to the manner, yet they could not have been more faithfully registered, as to the events. Which though I dare promise myself, that most readers will be induced to believe, upon the considerations not long since intimated; yet I think it requisite to give this intimation on this occasion, because, that though I have (in the two essays of the *Unsuccessfulness of Experiments*) largely manifested to what contingencies divers experiments are liable, yet I have found very few, whose events are so subject to be varied, by slight and not easily heeded circumstances, as several experiments concerning cold; where oftentimes the degree of that quality, or the time during which it continues applied, or the manner of application, or the thickness, shape and bulk, &c. of the vessels, that contained the matter exposed to it, may have a far greater influence on the success, than those, that have not tried, can easily imagine. And it increases the difficulty, that these experiments of ours being (very few excepted) the only, that are yet made publick concerning cold; we cannot so easily, as in other cases, free ourselves from the doubts, that may be suggested by different events, by comparing together several experiments of the same kind; though to obviate this inconvenience, as far as I may, I have divers times in cases, where the experiments seemed like to be thought strange, or to be distrusted, set down several trials of the same thing, that they might naturally support and confirm one another.

OF those contingent experiments about cold, I was newly speaking of, the reader may meet with an eminent example in the 21st title, where mention is made of the differing effects of air blown out of a pair of bellows upon a weather-glass: and as for the suspicion I there conclude with, (though I yet doubt, whether it will reach all the cases incident to that experiment) I have since been confirmed in it, by finding, that by purposely varying the tempers of the bellows themselves, I could divers times considerably vary the operations, which the winds, blown out of them in their differing states, had upon the liquor in the weather-glass*. Of this I expect to have an opportunity of saying more, and therefore shall at present add but this one particular, which may sufficiently justify me for having said, that weather-glasses and our sensories may give very differing informations about the temperature of the air turned into wind, by being blown out of the same pair of bellows. For having taken two hermetically-sealed weather-glasses furnished with highly rectified spirit of wine, and purposely made for my experiments by a person eminently dextrous in making such instruments, and having likewise provided a large pair of bellows, I found, that by blowing twenty blasts at a time on the ball of one of them, though the pipe were not

* Another remarkable instance of the variable success of the experiments of cold I have met with in an experiment of the learned Dr. Merret's, about the congealing of oil of vitriol. For though I exposed that liquor in small vessels of differing sizes and shapes, and even in slender glass pipes, sealed but at one end, yet neither the cold of the air in frosty nights, that were extraordinarily sharp, nor, which is more, our frigorick mixture of ice and salt, would make the experiment succeed; notwithstanding that we tried it with several parcels of oil of vitriol. And yet, that the learned doctor by the help of the air alone (for he uses not our frigorick mixture) did bring that liquor, either to a true congelation, or a coagulated substance, that looked just like ice, both some eminent Virtuosi, and I my self, who had the curiosity to examine it, can bear him witness.

only slender, but of an unusual length, amounting to about thirty inches, yet the liquor did not sensibly subside any more than rise. And in the other weather-glass, whose pipe was less long, but whose ball was purposely made far greater to be the fitter for short and nice experiments, we found more than once, (and that as well in the cold air, as in a close room) that the wind, that was blown in divers blasts out of the bellows against the lower part of the instrument, did not only make the spirit of wine subside, but did make it manifestly, though but very little, ascend. And it is not necessary for the making good of what I taught, that such trials should always succeed just as these did, since it may suffice to prove what I pretended, that a good sealed weather-glass did divers times discover the wind to be rather warm, than cold, when upon trial (then purposely made) it felt not only manifestly, but considerably cold, both to a by-stander's hand, and to my own hand and face, though my hand, that was blown upon, were immediately before more than ordinarily cold.

AND I shall here add, that judging it fit to make further trial with an unsealed weather-glass, I made one, that was in some regards preferable to those mentioned in the second preliminary discourse, by making the bubble large, and the cylindrical pipe so proportioned to it, that instead of a drop of water, a pillar about an inch long of that liquor was kept suspended, and played as well conspicuously as nimbly up and down in the pipe: and having fastened this instrument in an erected posture, with the spherical part uppermost, to the inside of a window, by blowing upon the ball with the bellows above-mentioned, which had lain some hours not very far from the chimney-corner, (but without seeming to be sensibly warmed by the neighbourhood of the fire) a very few blasts made the suspended water hastily subside, (and thereby witness the expansion, and so the warmth of the included air) and upon my ceasing to blow, the same water would re-ascend in the pipe, and that, though I stood near it to watch it, (which shews, that the former depression was not caused by the approach of my warm body) and this I did more than once both alone and before witness, notwithstanding that the air blown at the same time out of the same bellows upon our hand and face seemed cool enough. But fearing to insist any longer in this matter in a Preface, I think it now unseasonable to add, that as some contingent experiments in subsequent trials may fail oftener, so others may, perchance, succeed oftener than is expected: as I have sometimes observed in the figures, that appear in the ice made of some liquors, that abound with volatile, urinous, or with certain other salts. But to say a word in general of experiments, whose success is not always uniform; as a magnetick needle, though it do not always precisely respect the poles, but both declines sometimes eastward, and sometimes westward, and varies that declination uncertainly as to us, does nevertheless so far respect the North, as in spite of its variations to be an excellent guide to navigators; so there are contingent experiments, whose events, though they sometimes vary, are seldom very exorbitant, but for the most part are regular enough to afford philosophers very useful informations and directions.

If it be demanded, why in the 15th, 18th, and 19th sections I have inserted so many quotations out of several authors, and how that agrees with what I have said, not far from the beginning of this Preface, of the uncultivatedness of the subject I have ventured on; I answer, that what I have done crosses not what I have said. For my complaint was, that there has been very little, especially of any moment, delivered concerning cold, by classick authors; and that even other learned writers, who have had occasion to say something purposely of cold, have handled it exceedingly jejune: but this hinders not, but that if a man will take the pains to seek

out, and inquire of travellers, and has the curiosity to consult voyages and navigations, he may, among a multitude of other things, that have nothing to do with cold, meet with some few, that concern that subject: and yet the authors, that deliver such particulars, can no more properly be said to have written professedly of cold, than of botanicks, or zoology, or meteors, or civil philosophy, because in the same journal they mention a great frost, or a great snow, as chancing to happen on such a day, with as little particular design, as they mention a storm, or a whale, or a bear, or the manners of an Indian people. This consideration being premised, it will not be difficult to return an answer to the former part of the question lately proposed. For the unfrequency of my quotations in most of the sections of the following history will, I presume, sufficiently persuade the reader, that I would not needlessly employ so many of them in the three sections, that are named in the quotation. But the writers of physicks being, for aught I know, silent as to the particulars I have transcribed out of other writers, and the observations being such, as I could not myself make in this temperate climate: I must either make use of other men's testimonies, or leave some of the remarkablest phenomena of cold unmentioned. And they, that shall try, how much pains it will cost them, to range among books, which many of them contain little but melancholy accounts of storms and distresses, and ice, and bears, and foxes, to cull out here and there a passage fit to make a part of such a collection, as they may here meet with, will possibly rather thank, than blame me, for having, to gratify my readers, given my self so laborious and unpleasant an entertainment. And I was the rather content to enlarge a little on the fore-mentioned occasions, not only because I was unwilling to be engaged more than once in so troublesome an employment, but (and that chiefly) because most of the particulars, I have collected out of navigators, are afforded me by the voyages of our own countrymen, who having written only in English an account of what their relations contain of most material concerning cold, will probably be welcome, as well as new, to the curious of other countries, who cannot understand their books; divers of which having been long out of print, are so hard to be procured, even here in *England*, that I doubt not, but these extracts of them will be acceptable, even to divers of the virtuosi of our own nation; especially since I have been careful to alledge most of the testimonies in the writer's own words, though they are not always the best, wherein the things he delivers might be expressed. And this course I the rather took, that I might do what I think very useful to be done by all writers of natural history, who would do well to distinguish more carefully, than hitherto many have done, betwixt the matters of fact, they deliver as upon their own knowledge, and those, which they have but upon trust from others. I know it would be more acceptable to most readers, if I were less punctual and scrupulous in my quotations; it being by many accounted a more genteel and masterly way of writing, to cite others but seldom, and then to name only the authors, or mention what they say in the words of him, that cites, not theirs, that are cited. And there are some writers of such known diligence and veracity, as to be safely trusted, and some cases, wherein I do not dislike, but comply with this custom, (after having first consulted my author to be master of his true and genuine sense) but in matters historical, and whereon philosophical and important truths are to be built, I should think my self beholden to a writer, for setting them down in such a way, as that I may satisfy my self, that the testimony is faithfully reported. In order to which, it will be sometimes very useful to be enabled to repair to the original witness, and, if need be, survey there the context of the alledged passage. For I must here advertise the reader, that in matters of any moment, it is not from every writer, that I dare trust the quotations he

makes

makes of the passages of other authors, in his own words, not theirs: for upon comparing very many quotations, I have found, that oftentimes there is no such thing, as is pretended to be really met with in the place referred to; and even when neither the book, nor chapter, nor page are misquoted, I have too frequently found, that the alledgers of testimonies do either, through inadvertency, misapprehend, or miscite the sense of the author they quote, or out of design make him speak that, which may comply with their own purpose, whether it were his own sense or no: and by their indefinite citations made it too troublesome and difficult a work, for the reader to find out, whether they have imposed upon him or not. But it is only by the by; to return therefore to the passages we were speaking of, in the 15th, 18th, and 19th sections, I shall now add, that having in the beginning of the XIXth title of the ensuing history itself rendered an account of my not scrupling to assert some strange relations concerning cold, it will not be requisite to mention here, what the reader will meet with there. And I scarce doubt, but he will excuse such passages, if we consider, that as I could not omit them, without leaving out some of the eminentest phænomena of cold, so being unable to examine them here in *England*, all I could do was, to report them faithfully, and mention only such, as were either affirmed by eye-witnesses, (as the most I have inserted, are) or, at least recommended by credible testimony, whereof we shall say more by and by: to which sort of narratives I know not whether I may refer that, which (yet for its strangeness may deserve a transient mention) came a-while since to my ears, of an Englishman, who related to an eminent virtuoso of our acquaintance, that a Dutch master of a ship, returning from the northern countries, very solemnly affirmed, being therein seconded by one of his countrymen, and offered to produce his journal for proof, that endeavouring to sail northwards as far as he could, he came within less than a degree of the pole itself, and found the sea open, and the cold very tolerable. But to return to what we were saying, before this odd relation diverted us, I did not only decline the mention of divers things, with which I fear many writers would have adorned a history of cold; but even of those, that I my self have inserted, I would have left out divers, were it not, that many of the relations, that may appear so wonderful, seem not to me to be repugnant to the nature of things, but only suppose a far greater degree of cold, than we have in these parts; and yet the familiar effects of the cold we have here, would, perhaps, be looked on as incredible, by one, that was born and bred in the kingdom of *Congo*, where *Odoardus Lopez*, who lived long there, informs us, that ice, that is, water made solid, is so known a rarity, that it would there be valued as so much gold. And a learned physician, that lived in *Jamaica*, being asked, how far he found the temperature of that country to be like that of *Congo*, answered me, that in that island he observed not all the winter long, either frost or snow. And yet here it will not be unreasonable to say a word or two of the three principal authors, from whom most of our strange relations we are considering, are transcribed.

THE first is *Gerat de Veer*, who writ the voyage of the Hollanders to *Nova Zembla*, a book so eminent in its kind, that it may seem a wasting of time to set down a character of it; and therefore I shall only advertise the reader of two things; the one, that the Dutch did, indeed, make three consecutive voyages to *Nova Zembla*; but that the third being that, in which they wintered there, most of the particulars are to be understood of that. The other thing is, that having lost the translation, that was made of those voyages out of Dutch into English, (published in a book by themselves) without being able to procure another, I was obliged to have the citations transcribed, as I found them extant in that faithful collection of voyages compiled by

Purchas;

Purchas; who seems, by the style, to have (as to the book we are speaking of) only plaid the part of an interpreter. And here it will be seasonable to add, that whereas that excellent collection consists of several distinct tomes or volumes, the many quotations to be met with, in the margin of our history under the name of *Purchas*, are to be understood (unless the contrary be intimated) to belong to the third part of his *Pilgrim*, where the Dutch and other voyages into the northern countries are to be found.

THE next book I intend to mention, is *Olaus Magnus's History of the Northern Nations*. And though this author is of very suspected credit, and delivers some things upon hear-say, which they are kinder to him, than I, that are pleased to believe; for which reason I do but very sparingly make use of his history; yet, considering, that he was archbishop of *Upsale* in *Sweden*, and appears to have more learning, than many, that never read his books, imagine; I thought I might, now and then, make use of his testimony in matters, wherein he either professes himself to speak upon his own knowledge, or delivers but such things, as being consistent with the laws of nature, appear improbable, only, because of the intense cold, that they suppose: which I the rather say, because he himself somewhere speaking of the cold, that by the laws of nature reigns in the North, subjoins this passage, (*Lib. i. Titulo de frig. asperitate*, page 9.) *Sub quo quia natus, & versatus sum etiam circa elevationem graduum poli arctici 86, arbitror me posse hoc, & multis sequentibus capitulis, nonnihil cæteris vaga opinione scribentibus clarius demonstrare, quam vehemens & horrendum sit illic frigus.*

AND, though perchance few readers will perceive it, I have been so severe in rejecting not only relations, but even authors not otherwise obscure, that, how much soever I foresaw my scrupulousness might impoverish my history, yet there are some whole treatises about cold countries, whence I have shunned to borrow any one authority, because I perceived the authors had not observed the things they recount themselves, and were too easy in believing others.

THE third writer I meant to take notice of, is captain *James*, a person from whose journals I have borrowed more observations, than from those of any other seamen, not only because his book supplied me with them, and because it is somewhat scarce, and not to be met with in *Purchas's* tomes, (having been written some years after they were finished) but because this gentleman was much commended to me, both by some friends of mine, who were well acquainted with him, and by the esteem, that competent judges appear to have made of him. For having been, not only employed by the inquisitive merchants of *Bristol*, to discover a north-west passage into the South-sea, but designed for so difficult a work by so judicious a prince, as the late king, and having, at his return, published his voyages by his Majesty's command; as by these circumstances, though not by these only, this gentleman's relations may well be represented to us, as likely to deserve our consideration and credit; so, by his breeding in the university, and his acquaintance with the mathematicks, he was enabled to make far better use than an ordinary seaman would have done, if the opportunity he had to observe the phenomena of cold, by being forced to winter in a place, where he endured little (if at all) less extremity of cold, than that of *Nova Zembla*.

I PRESUME it will easily be taken notice of, that in the following history I have declined the asserting of any particular hypothesis, concerning the adequate cause of cold. Not but that I may have long had conjectures about that matter, as well as other men, but I was willing to reserve to myself an intire liberty of declaring what opinion I most inclined to, till the historical part being finished, I may have the better opportunity to survey and compare the phenomena; and the leisure, (which I cannot promise myself in haste) of calmly considering what theory may best agree with them: especially

especially since I freely acknowledge, that I found the framing of an universal and unexceptionable hypothesis of cold to be a work of greater difficulty, than every body would imagine; especially to me, to whom some experiments, purposely made, have suggested a puzzling difficulty, which it is like that philosophers have not yet thought of. And whatever applause is wont in this age to attend a forwardness to assert hypotheses, yet, though fame were less to be fought than truth, this will not much move me, whilst I observe, that hypotheses hastily pitched upon do seldom keep their reputation long; and divers of them, that are highly applauded at the first, come, after a while, to be forsaken, even by those, that devised them.

As for the title of the following book, I call the experiments new, because indeed, if I mistake not, nine parts of ten (not to say nineteen of twenty) are so. But though 150, or 200 experiments of that kind, besides collections from travellers, and books, that do not professedly treat of cold, may, I presume, allow me to have begun the natural history of cold; yet, in the very title-page I think fit to intimate, that I look upon what I have done but as a beginning. For though some very noted virtuosi have been pleased to seem surprized, to see what so barren and uncultivated a subject has been brought to afford this treatise; yet I look upon these as things, that do rather promise than present a harvest, and but as some early sheaves of that crop, which men's future industry will reap from a subject, that is indeed barren, but not unimproveable. For I see not, why it should not hold in the history of cold, as well as in many other attempts, that the greatest difficulties are wont to be met with at the beginning; and those being once surmounted, the progress becomes far more easy. And as the magnetick needle, though it point directly but at the north and south, does yet discover to the seaman the east and west, and all the other points of the compass; so there are divers experiments, which though they do primarily and directly teach us but a notion or two, may yet assist us to discover, with ease, many other truths, to which they seemed not at first sight to afford us a direction. So that what is here already done, such as it is, partly by hinting various inquiries about cold, and partly by suggesting ways not formerly practised of making farther experiments, may possibly make it more easy for others to add to these a number, far exceeding that, which they will here meet with, than it would have been without such assistances, (which I had not) to contribute to the History of Cold, even such a stock as I have begun it with. And this I the rather incline to think, because I find, that when once a man is in the right way of making inquiries into such subjects, experiments and notions will reciprocally direct to one another, and suggest so many things to him, that if I were now to begin this work again, and had cold, and fitly-shaped glasses, and instruments, with other accommodations at command, there are divers parts, on which my enlargements would not, perchance, be much inferior to what is already extant there, if they did not much exceed it. But besides that I have other work enough, and that of a quite other nature upon my hands; the truth is, that I am plainly tired with writing on this subject, having never handled any part of natural philosophy, that was so troublesome, and full of hardships, as this has proved; especially because that not only the experiments being new, and many of them subject to miscarriages, required to be almost constantly watched, but being unable to produce or intend cold, as we can do heat, nor command the experiments, that concern congelation, with as little difficulty, as we can do those, that belong to divers other subjects; I was fain to wait for, and make use of a fit of frosty weather (which has very long been a rarity) as solicitously as pilots watch for, and improve a wind.

III. It remains now, that I give some account, why I suffer so unfinished a piece, as I acknowledge this to be, to come forth at this time. And I confess, that if I had
not

not preferred the gratifying the curious, before the advantages of my reputation, I should have kept this book in my hands some winters longer, that it might come forth, both more rich, and less unpolished. But how great a power my friends have with me in such cases, the reader may easily guess by the preamble he will find prefixed to the first title of the ensuing history. For by the date of that, he will see, how early my papers about cold were to have been communicated; nor was I any thing near so much befriended, as I expected, by those interposing accidents, that have for above a year and half kept those papers lying by me. For the then next, and now last winter proved so strangely mild, as to be altogether unfavourable to such a work as I had designed. Wherefore finding, that delays had done me no more service, and pressed by the solicitations of divers virtuosi from several parts, I resolved, that I would suspend till another opportunity the drawing together of what I had observed or collected, touching the regions of the air, and some of the chief hypotheses, that are controverted about cold, with what other loose papers, touching that quality, I could not so readily dispatch to the press; and would not withhold from the curious what assistance my collections could afford them, to make use of this winter to prosecute experiments of cold. And remembering how favourable an entertainment my former endeavours to gratify ingenious men had found among them, I took a course, wherein I was more likely to obtain thanks than praises, and chose rather to adventure on the equity and favour of the reader, for the pardon of those faults and imperfections, that are imputable to haste, than to deny him the opportunity of this cold season, wherein to examine the truth, and supply the deficiencies of what I had delivered. And this I the rather did, both because I was desirous to quit this subject for another, from which it had diverted me, and for which I have more value and kindness; and because, that as a tender constitution of body kept me, whilst I was writing the following history, from adventuring upon some trials, that might (probably) have enriched it; so the continuance of the same disadvantages, together with other inopportune distempers superadded to them, do not permit me to know, whether, and how far I shall be able to prosecute the work I have begun; and do oftentimes reduce me to be more concerned to shun the effects of cold, than observe the phenomena of it. And indeed, whether those prove true prophets or no, that assure me I shall lose no reputation by this history (as incomplete as it comes forth) I think, if ingenious men knew, how much trouble and exercise of my patience it has cost me, they would, peradventure, vouchsafe me some of their thanks, if not for what I have done, yet for what I have suffered for their sakes, (and would scarce have undergone upon any inferior account whatsoever;) it being, though a less noble, yet no less troublesome an employment, to dig in mines of copper, than in those of gold; and men being oftentimes obliged to suffer as much wet and cold, and dive as deep, to fetch up sponges, as to fetch up pearls.

THERMOMETRICAL EXPERIMENTS and THOUGHTS.

DISCOURSE I.

Proposing the first Paradox, *viz. That not only our Senses, but common Weather-glasses, may misinform us about Cold.*

IT may to most men appear a work of needless curiosity, or superfluous diligence, to examine solicitously, by what criterion or way of estimate the coldness of bodies, and the degrees of it are to be judged; since coldness being a tactile quality, it seems impertinent to seek for any other judges of it than the organs of that sense, whose proper object it is. And accordingly, those great philosophers, *Democritus, Epicurus, Aristotle*, and (till of late) all others both ancient and modern, seem to have contented themselves in the matter with the reports of their sensories.

BUT this notwithstanding, since we can scarce imploy too much care and diligence in the examining of those touchstones, which we are to examine many other things by, perhaps it will be neither unseasonable nor useless to premise something touching this subject.

FOR though it be true, that cold in its primary and most obvious notion be a thing relative to our organs of feeling, yet since it has also notable operations on divers other bodies besides ours; and since some of them seem more sensible of its changes, and others are less uncertainly affected by them, it would be expedient to take in the effects of cold upon other bodies, in the estimates we make of the degrees of it.

AND to make this appear the more reasonable, I shall not scruple to propose the following paradox; namely, That our sensories, either alone, or assisted by common weather-glasses, are not too confidently to be relied on in the judging of the degrees of cold.

To make this paradox plausible (which is almost as much as I here pretend to) I shall represent in the first place, that the account, upon which we are wont to judge a body to be cold, seems to be, that we feel its particles less vehemently agitated than those of our fingers, or other parts of the organ of touching. And consequently, if the temper of that organ be changed, the object will appear more or less cold to us, though it self continue of one and the same temper.

THIS may be exemplified by what has been observed by those, that frequent baths, where the milder degrees of heat, that are used to prepare those, that come in for the higher, seem very great to them, that coming out of the cold air, dispose themselves to go into the hot baths, but are thought cold and chilling to the same persons, when they return thither out of much warmer places; which need not to be wondered at, since those, that come out of the cold air, find that of the moderately warm room more agitated, than the cold ambient would suffer the external parts of their bodies to be; whereas the same warm air, having yet a less agitation than that, in which the hotter parts of the bath had put the sensitive parts of the bathers bodies, must seem cold and chilling to them.

BUT it is not only in such cases as this, wherein men can scarce avoid taking notice of a manifest change in themselves, that these mistaken reports of our senses may have place. For oft-times we are imposed upon by more secret changes in the disposition of our sensories, when there needs something of attention and of reasoning, if not of

philosophy, to make us aware of them. For being apt to take it for granted, that our temper is the same, when there is no very manifest cause, why it should be changed, we often impute that to objects, whereof the cause is in our selves; and if this change in our selves be wrought by unsuspected agents, or by insensible degrees, we do not easily take notice of it. Thus though in summer divers cellars, that are not deep, are perhaps no colder than the external air was (when it was judged but temperate) in winter or the spring; yet it will seem very cold to us, that bring into it bodies heated by the summer sun, and accustomed to a warmer air; nay, cold does so much depend upon the degree of agitation in the parts of the object, in reference to the sentient, that even when we may think the sensory unaltered, it may judge an object to have a degree of coldness which indeed it hath not; as I remember, that to satisfy some friends, that it is not every wind, which feels cold to us, that is really more cold than the still air, I have sometimes shewn, that in not nice weather-glasses, air blown out of a pair of bellows does not appear to have acquired any coldness by being turned into wind, though if it were blown against the hands or face, it would produce a new and manifest sense of cold: of which the reason seems to be, that though the organ in general seems not to be altered, yet the wind, by reason of its motion, is able not only to drive away the parts of the air contiguous to the hand or face, and the warm steams of the body, which tempered its coldness; but to pierce deeper than the calm air is wont to do into the pores of the skin, where, by comparison to the more inward and hotter parts of the sensory, it must needs appear less agitated and consequently colder.

BESIDES that sometimes we may meet with certain steams in the air, that have in reference to the blood and spirits of human bodies (though not perhaps to divers other liquors) a certain hidden power of chilling, as opium, even in outward applications; (for in such ways I have known a great surgeon much use it and highly extol it) strikes a coldness into the body by the subtle effluvia, that insinuate themselves at the pores of the skin; and perhaps too that coldness is ascribed to external bodies, which is produced in us by some frigorifick vapour, or other distemper: which being too slight to be taken notice of as a disease, may yet be of kin to those agents, that produce what physicians call horrors and rigours at the beginning of fevers, and some other distempers; or produce that strange and universal coldness of the external parts, which is frequently enough observed among other symptoms in hysterical women. Moreover, bodies may often appear colder to us than to a weather-glass, because our sensories are more affected by the density and penetrancy of the parts. This may seem somewhat strange, but being suitable enough to some of my conjectures about cold, I have often made trials with very nice weather-glasses, that have assured me, that (at least oft-times) when water seems to be cold enough to our touch, it appears not to be colder to the weather-glass than the ambient air.

THESE trials I have sometimes made with sealed weather-glasses, but the most with another sort of weather-glasses (whose structure and use are by and by to be mentioned) which though they seldom prove durable, nor of any great use in any other than such nice and short experiments, yet they discover slighter changes of the temper of the air, than would be notable (not to say sensible) in ordinary thermometers. But of multitudes of trials, that I sometimes made with these glasses, I can at present find among my loose papers but a very few; and though I remember, that in one or two (made about the same time with some of those that follow) I observed things, that make me now wish I had had opportunity to make those further trials of them, which some of their phenomena seem to direct the making of; yet I shall annex these that follow, as I find them entered, because they

they are not perhaps destitute of hints improveable by further prosecution. *June 26.* between two and four in the afternoon (the weather moderate for the season) I took a thin white glass-egg blown at a lamp about the bigness of a walnut, with a stem coming out of it about the bigness of a large pigeon's quill four or five inches long, and open at the top; this slender pipe being dipped in water, admitted into its cavity a little cylinder of water, of half an inch long or somewhat more, which (the glass being erected) subsided by its own weight, or the temper of the air in the egg (in reference to the outward air) till it fell to the lower part of the pipe, where it comes out of the egg, and thereabout it would rest. Now if taking this glass by the top betwixt my thumb and forefinger, I depressed the egg under the surface of a basin of fair water (cold enough to the touch) the little aqueous cylinder, that parted betwixt the air in the egg, and the external, would, instead of being made to subside by the egg's immersion into cold water, presently rise up from the lower part of the pipe, till it reached about the middle of it, though the glass were, in this and the following trials, held erected; and as soon as it was taken out of the water into the air, the water would again subside, whether I held the glass, or let it rest upon the boards, or a linnen carpet, that covered the tables, on which the trials were made. And this I did several times as well with as without witnesses. I tried also that if, instead of water, I made use of quicksilver, though not big enough to cover the egg much above half way, and in the rest proceeded as above; the cold quicksilver would presently make the aqueous cylinder hastily ascend near three inches, sometimes almost, and sometimes quite to the top of the slender pipe, whence the water would again quickly subside, when the glass was taken out into the free air, or set to rest upright as before.

BESIDES, having set the vessel of quick-silver and the basin of water very near one another, I did at least upon three or four several trials find, as I expected, that when by immersing the egg in water, the pendulous cylinder was raised so high, that it did no longer sensibly ascend, by nimbly taking the egg out of the water and depressing it in the quicksilver, it would rise far higher: and I also tried, that nimbly removing the egg out of the quicksilver into the water, the pendulous cylinder would subside, after plunging the egg under water, though not so fast, nor near so low, as it would do, in case the glass were removed from the quicksilver into the air. Upon another trial made much about this time, though not the self-same day; the pendulous water in the same glass, (the day being for the most part windy and rainy) did subside upon the immersion of the glass into water, not only a while before noon, but an hour or two after dinner, and at distant hours afterwards, though the descent of the pendulous water was neither quick, nor so considerable, as it had been formerly in the mornings.

June 27. In the morning a small cylinder of water pendulous in the above mentioned glass, upon the immersion of the egg in a basin of water, would immediately and very considerably subside; whereas the same glass, being immersed in the vessel of quicksilver formerly mentioned, would presently ascend. Both parts of this experiment we several times tried, and the reason was suspected to be, that the quicksilver had staid all night in my chamber, which was somewhat warm, whereas the water was brought up that morning, and to the touch seemed colder than the quicksilver; and a while after dinner, the same water having been still kept in the room, we divers times found, that as well that, as the quicksilver, did immediately, upon immersion, impell up the pendulous water in the slender pipe. Another time in the frosty weather (and about the beginning of *January*) we did with such a glass (as has been already several times mentioned) take some drops of water out of a vessel, wherein that liquor had for a good while been kept; that it might be reduced as near as we could to the

temperature of the ambient air; then suffering the suspended water to continue a convenient while in the long and slender stem of the weather-glass, that the internal air might be reduced to the temper of the external, we took up the glass by the open end; and immersing the obtuse part of it into a shallow vessel, containing some of the above mentioned water, we found the suspended drop suddenly impelled upwards about half an inch or more, and the ball of the thermometer being taken out of the water into the air, the pendulous drop did again (though far more slowly than it ascended) subside. This was repeated three or four times with some intervals between (and that in a room where there was no chimney) and still with the like success, save that in the two last trials we took the weather-glass out of the shallow water, and plunging it into a deep vessel of the same water (that stood very near the other) we found (for further confirmation of the experiment) that the pendulous water was, upon these new immersions, impelled up, near (if not full) as high again, as when we had immersed it only in the shallow vessel: and taking it out of this deep glass, we found the cold of the external air to reduce it to its former humble station. Thus far the notes, I have yet been able to recover: and though, as I said, I dare not build very much upon them, yet by small sealed weather-glasses I find enough to invite me to suspect, that of the degrees of heat and cold in the air we may receive differing informations, when we employ only our organs of touching, and when we make use of fit instruments.

I SHALL add on this occasion, that not only water itself, but moist vapours abounding in the air, may make us think it colder than the weather-glass discovers it to be. For though it be generally taken for granted, that the thermometer does only more exactly measure or determine the effects, which cold hath both upon it and upon our sensories; yet I have long suspected there is somewhat else in the case, and I have observed, that sometimes the weather seemed more or less cold to me, than that which preceded, when the contrary appeared in the weather-glass; and that, when upon consideration of the whole matter, that difference did not appear to depend upon those circumstances of exercise or rest, or the temperature of the air I came out of, or any of those other things, to which a considerate man, that goes upon no better than the common opinions about weather-glasses, would be apt to impute to that phænomenon. And I was the less disposed to think my self mistaken, because having purposely enquired of others in the same house, who were not told, what information the weather-glass gave, they agreed with me in the sense I had of the temperature of the weather. And having since, as occasion served, communicated my observations and suspicions to divers ingenious men, I have been by their recenter observations confirmed, that what I have taken notice of, was not the effect of any *Ἰδιόσυγγρασία*. From which and other particulars, that we may have elsewhere opportunity to mention, we may plausibly enough infer, that it were not amiss, not only to take notice, when we have opportunity, of the sense, that is expressed of the degrees of cold by birds and other animals, whose diet is more simple and regular than ours, and whose perceptions are commonly more delicate and less diverted; but especially, to examine the coldness of the air and other bodies as well by experiments and instruments, as by the touch. And on this occasion I must not pretermitt that memorable account, that is given us by *Martinus*, in that noble piece of geography, which he calls *Atlas Chinenfis*, where speaking of the air of that populous country, he has this singular passage: *Ad cæli* (says he) *solique temperiem quod attinet, majus in hac provincia frigus est, quàm illius pæseat poli altitudo; vix enim illa excedit gradum secundum supra quadragesimum; & tamen per integros quatuor sæpe menses flumina omnia aded durè concresecunt gelu, ut currus equosque ac gravissima etiam onera glacies ferat, innoxie ac securissimè transeant: ex his ingentia*

ingentia etiam glaciæ frusta excinduntur, quæ in futuram æstatem ad delicias servant. His mensibus omnes naves ita in ipsâ glaciæ defixæ sunt, ut progredi nequeant ubicunque illas frigus occupat (quod certo certius circa medium Novembris ingruere solet) per quatuor illos menses immotæ ibi perstare coguntur, neque enim resolvitur glaciæ ante Martii initium; hæc plerumque glaciæ concretio uno fit die, cum non nisi pluribus fiat liquefactio. To which he adds, what makes most to our present purpose, omnino illud mirum, tantum non videri aut sentiri illud frigus, ut Europæos ad hypocausta subeunda videatur posse cogere, aut in Europâ ad glaciem producendam sufficere, unde ad subterraneas illic exhalationes pro harum rerum causis indagandis omnino recurrendum est, &c.

BUT all that I have been implying of the necessity and usefulness of the weather-glass, is no ways inconsistent with the truth of the latter part of our formerly proposed paradox; namely, that we are not rashly to rely upon the informations even of common weather-glasses themselves. For though they be an excellent invention, and their informations, in many cases, preferable to those of our senses, because those dead engines are not, in such cases, obnoxious to the same causes of uncertainty with our living bodies; yet I fear they have too much ascribed to them, when they are looked upon as such exact instruments to measure heat and cold by, that we neither can have, nor need desire any better. For, not yet to mention some inconveniencies in the contrivance of them, which makes them unapplicable to some purposes, and less proper in others, than thermoscopes might be made, even in divers cases, wherein they are presumed to be unexceptionable, their reports are not to me, I confess, quite exempt from suspicion. For, in ordinary weather-glasses, some part of the liquor being contiguous to the external air, it is subject to be impelled more or less upwards, not only according as heat or cold affects the included air, but according as the incumbent air happens to be heavier or lighter. And though this be a thing not taken notice of by those, that have treated of weather-glasses, yet after what we have elsewhere manifested concerning the weight and spring of the air, and what we have probably conjectured concerning the varying height of the mercurial cylinder in the Torricellian experiment; I see not why it should not much call in question the informations we receive from common weather-glasses in those cases, where the height or weight of the atmospherical pillar, that presses upon the water in the weather-glass, is considerably longer or shorter, lighter or heavier than is usual.

See the 18th
of our New
Physico-
Mechanical
Experi-
ments.

FOR besides the reason of the thing, we have experience on our side. I might mention, on this occasion, an experiment I thought on, and also attempted, last winter, to show, even upon a ballance, the varying gravity of the atmosphere in one and the same place, by hanging a small metalline weight at one end of a pair of scales so strangely exact, that they would turn with far less than the five hundredth part of a grain; and counterpoising it at the other end with a hermetically sealed glass bubble, which being blown as large and as thin as could possibly be procured of so small a weight, might, by its great disproportion in bulk to the metalline body, lose more of its weight than that would upon the ambient air's growing more heavy. But the particular account of this attempt belonging to another place, the trial ought not be more than hinted here; especially since it may suffice for our present purpose to alledge, that having found (as we have already in other papers noted) that in a weather-glass, where the water is not fenced from the external air, the weight of the atmosphere may make it alter considerably between the top and the bottom even of a church or steeple, though it appeared by more certain thermoscopes, that it was not the differing temperature of the air, as to cold and heat, but the differing gravity of the atmosphere, which being shorter and lighter at the top, pressed less forcibly upon the subjacent water and the included air, as is more fully made out in the treatise
above.

In the De-
fence against
Linnæus, chap.
4.

above related to. And having, by the intervention of a learned acquaintance, desired to have some experiments made of the effect of the air upon weather-glasses in deep pits or mines, where the atmospherical cylinder is longer and heavier, I received information, that an ingenious physician, (Dr. H. P.) who had the opportunity of trying what I desired, had found, that in the bottom of one of those very deep pits, the water, in a common weather-glass, rose near three inches higher than at the top, in a shank or pipe of about thirty inches long. And this notwithstanding the warmth, that is usual in such deep places, which seems not any thing near so plausibly referrible to any other cause, as to the increased gravity of the atmospherical pillar incumbent on the water, that pillar being heavier at the bottom than at the mouth of the pit, by the weight of an aerial pillar equal in length to the pit's perpendicular height or depth.

BUT these are not the only cases, wherein the differing gravities of the atmosphere may, as well as heat and cold, have an interest in the rising and falling of the liquor in common weather-glasses. For though you should not remove them out of one place; and though consequently it may seem, that the atmospherical pillar, that presses upon the water, must be still of the same length, yet (not to urge, that that may alter unknown to us) if retaining its length it retain not its gravity, we may be easily imposed upon, and take that ascension or subsidence of the liquor for the effect of a higher or remiss degree of cold, which may either totally or at least in part (and in what part, we are left to guess) be the effect of the increased or lessened weight of the atmospherical pillar, happening either by the copious dispersion of vapours and other heavy steams through the air, or upon other occasions not necessary to be here discoursed of, or by the precipitation of such vapours by rain, or into dew, or else by the removal of the occasions of the augmented gravity or pressure of the air. For we have often observed great variations to happen in the height of the mercurial cylinder, in the Torricellian experiment, upon great rains and fogs, and other sudden and considerable mutations of the incumbent air. But since I myself thought fit, notwithstanding the plausible ratiocination, that led me to this conjecture, to examine it by experience; I can scarce doubt, but that others may have the like curiosity that I had. And therefore, because it may seem a paradox, it will not be amiss, of many to annex three or four trials I made to examine the proposed doctrine, especially ours having been the first observations of this kind, that, for aught we know, have been made by any. And indeed others could scarce have well made much, though they lighted on the same thoughts, for want of such sealed weather-glasses to make them with. To omit then those, that I made with a sealed weather-glass, and an ordinary one (in which the water remains suspended beneath the included air) I shall briefly relate, that in a room unfurnished with a chimney, I kept two weather-glasses, which, for more exactness sake, I caused to be made of a length far greater than ordinary; so that the divisions of the one were half inches, and those of the other not much less, and yet were numerous. The one of these, which was furnished with good spirits of wine, was sealed, the other not; but this last I caused to be so made of the shape represented by the scheme, that the air being shut up in the lower part of the instrument (not as in common weather-glasses at the top) the liquor might as well in this, as in the sealed weather-glass, rise with heat and fall with cold. In these thermoscopes (where the ascension and relapse of the liquors were, by reason of the length of the pipes, far more conspicuous than in vulgar weather-glasses) I observed, with pleasure, that the hermetical thermoscope (if I may for distinction-sake so call it, by reason of its being hermetically sealed) did regularly enough descend in cold weather, and ascend in warm: but the other, which was not sealed, but had a little hole left open

open at the top of the pipe, though, when the atmosphere continued of the same weight, it would, like the other, rise with heat and fall with cold, yet when the atmosphere's gravity was altered, they would not uniformly move together, but when (as we gathered from other observations) the atmosphere grew heavier, the liquor in the pipe did not ascend, as high as it would have done, if the atmosphere had continued in its former degree of gravitation. And, on the contrary, when the incumbent air came to be lighter, the liquor would rise in the open weather-glass in a proportion greater than the single increase of heat would have exacted; so that by comparing the two weather-glasses together, I did usually foretel, whether the mercury in the Torricellian tube (which I keep purposely by me in a frame) were risen or fallen, and consequently whether the external air were heavier or lighter than before: As, on the other side, by looking on the height of the mercurial cylinder, I could easily tell before-hand, whether the liquor in the open weather-glass were higher or lower than that in the hermetical; the rising or falling of the mercurial cylinder one quarter of an inch (the temperature of the air continuing as to heat and cold) usually signifying a great disparity betwixt the ascension or the falling of the liquors in the two instruments.

AMONG the several notes, I find among my loose papers, and in a diary I kept for a while of these observations, I shall content my self to transcribe the following two, because, though divers others were made by my Amanuensis, whose care is not to be distrusted, yet by reason of my absence I could not take notice of them myself. The first of these *Memorandums* runs thus.

LAST night I took notice, that there was but one or two divisions difference betwixt the two thermometers, but upon such a change of weather, that happened this day, as made me imagine, that the atmosphere would be lighter than before, consulting the barometer (if to avoid circumlocutions, I may so call the whole instrument wherein a mercurial cylinder of 29 or 30 inches is kept suspended after the manner of the Torricellian experiment) I found the quicksilver lower than it had been a great while, and thereupon concluding, there would be a notable disparity, between the sealed and open weather-glass, I hastened to them, and found that the latter being much alleviated from the weight of the incumbent air, was no less than 17 divisions higher than the others; and comparing the height the two instruments were this day at, with an observation I my self made about a week ago, when the quicksilver was much higher than now it is; I found, that although this afternoon the sealed glass being at 41, the other was 58; yet then, when the sealed weather-glass was five divisions higher, namely, at 46, the unsealed weather-glass was but at 27: So that betwixt that time and this, the liquor in the sealed weather-glass, has descended five divisions, but that in the open weather-glass has ascended 31.

THUS far the first of the above mentioned notes; the second is as follows.

THE mercurial cylinder being higher, than it has been a good while, and yet the weather warm and sun-shiny, when the liquor in the sealed glass stood very near the 50th division, that in the unsealed was fallen down as low as the 32d.

So that it is very possible, that the unheeded change in the weight of the external air may have a greater power to compress the included air in an unsealed weather-glass, than a not inconsiderable degree of warmth may have to dilate it; and consequently in an ordinary weather-glass, where the air is included at the top, it may often fall out, that contrary to what men suppose must needs happen, the pendulous water may rise in warmer weather and fall in colder.

AND

AND even since the writing of the immediately foregoing page, within a few days that intervened, I have myself made observations, that do yet more clearly manifest this truth, as may appear by the following notes. The first of which speaks thus.

Memorandum, THAT yesterday night the quicksilver being at 29 inches, the liquors in the sealed and unsealed weather-glasses were near about the same division, the former being at 40, and the other being but half a division short of that number. But this night the quicksilver being risen about $\frac{1}{4}$ of an inch; the liquor in the sealed is ascended to 45, and the other descended beneath 35 about half a division, so that there are now 10 divisions between them.

THIS the first note, to which the following night enabled me to add this other.

THE quicksilver being risen almost $\frac{3}{4}$ of an inch above the station it rested at, the night before last night, the hermetical weather-glass being as it was then above the 40th division; the liquor in the other, which was open, in two days and nights is fallen to the 17th, and consequently is subsided about 23 divisions, whilst the other is about the same height, at which it was at the beginning of that time.

Two, or three days after, being returned to the place, wherein I had made this last observation, and from which some urgent occasions had for that time exacted my absence; I found the disparity betwixt the two thermometers, that is expressed in the following memorial.

THIS day the quicksilver being risen to 30 inches, when the liquor in the sealed weather-glass was at about 41 divisions, that in the other was depressed a pretty deal below the 9th division; so that the difference between the two thermometers was increased since the last observation from 23 near to 33 divisions, all which the liquor in the open weather-glass had sunk down, whilst that in the sealed continued almost at a stand. And the day after this memorial, I had occasion to register another, which being the last, I shall here think requisite to take notice of in this discourse, I shall subjoin it with that, which immediately preceded in order of time.

THIS day the quicksilver continuing at the same height, at which I observed it yesterday, but the weather being grown much colder, the liquor appears in both the glasses to have uniformly enough subsided; that in the sealed weather-glass being about the 33d, and the other being sunk quite below the lowest mark of all, which was more than I apprehended it would have done, when there was no frost: especially since by my diary it appears, that one of the last times I observed the hermetical weather-glass to stand at near about the same height, namely, the 34th; the liquor in the other glass was no lower than 41: nor probably would there be now so great a difference, if the atmosphere had not been this day very heavy; whereas, when this freshly-recited observation was made, I find by the diary, the quicksilver to have ascended but to 29 inches, and a pretty deal less than a half.

SINCE that time, being forced by several avocations to be often absent from the place where my thermoscopes were kept, I was not careful to prosecute such observations, those already set down (not to mention those, that are not here transcribed) being judged abundantly sufficient to evince the paradox proposed to be proved by them: only to manifest, that after I desisted from registering my observations, the phenomena may probably have been as remarkable as before; I shall add, that one of the last times I chanced to take notice of the difference to be gathered by comparing the two weather-glasses, I found (the weather happening to be warmer than ordinary)

ordinary) the difference between them to exceed any, that I remembered my self to have then observed, amounting to 44, if not to 45 divisions.

AND even since the writing of the last line, we have had opportunity to observe a phenomenon, which if it had occurred to us in the place, where we might have compared the baroscope with the exact weather-glasses hitherto mentioned, (and whereby we had been invited to rely upon it) would perhaps appear more considerable, than any of the observations yet recorded. For not very many hours ago, finding in the morning the quicksilver to be risen in a good baroscope of mine (though another from that, all this while referred to, and elsewhere kept) above $\frac{1}{4}$ of an inch higher than the place it rested at the night foregoing, and a somewhat nice weather-glass (where the included air is kept in the lower part of the instrument, which is shaped like that already described in this discourse) being consulted to show, what effect so great and sudden a change of the atmosphere's gravity would have upon it; I saw the tinted liquor in the shank depressed a full inch or more beneath the surface of the ambient liquor in the phial, which strange depression of the liquor in a pipe above 20 inches long, and where the alterations of the air as to heat and cold are not wont to produce any thing near so great an effect, I could not but take much notice of. Since the season of the year makes it no way likely, that the night, though cold, could have had so powerful an operation on it, especially since an amanuensis, that watched it much longer than I, affirms, that he saw the liquor driven down quite to the very bottom of the pipe, and a bubble of the outward air to make its passage through the water, and to join with the air contained in the cavity of the phial.

DISCOURSE II.

Containing some new Observations about the Deficiencies of WEATHER-GLASSES, together with some Considerations touching the New or Hermetical Thermometers.

AND since I had occasion to speak of the deficiencies of weather-glasses, and the mistakes, whereto men are liable in the judgment they make of cold and heat upon their informations, it will not perhaps appear impertinent to add three or four considerations more, to excite men to the greater wariness and industry, both in the making and using weather-glasses, and in their judging by them.

I. AND first, I consider, that we are very much to seek for a standard, or certain measure of cold, as we have settled standards for weight, and magnitude, and time: so that when a man mentions an acre, or an ounce, or an hour, they, that hear him, know what he means, and can easily exhibit the same measure: but as for the degrees of cold (as we have elsewhere noted concerning those of heat) we have as yet no certain and practicable way of determining them; for, though, if I use a weather-glass long, it is easy for me to find, when the weather is colder, or when warmer, than it was at the time, when the weather-glass was first finished; yet that is a way of estimating, whereby I may in some degrees satisfy myself, but cannot so well instruct others, since I have no certain way to know determinately, so as to be able

to communicate my knowledge to a remote correspondent, what degree of coldness or heat there was in the air, when I first finished my thermoscope: for besides that we want distinct names for the several gradual differences of coldness, we have already declared, that our sense of feeling cannot safely be relied upon to measure them. And as for the weather-glass, that is a thing, which, in this case, is supposed to be no fit standard to tell us what was precisely the temper of the air, when itself was first finished, since that does but inform us of the recessions from it, or else that the air continues in the temper it was in at the making of the instrument, but does not determine for us that temper, and enable us to express it; as indeed it is so mutable a thing, even in the same place, and oft-times in the same day, if not the same hour, that it seems little else than a moral impossibility, to settle such an universal and procurable standard of cold, as we have of several other things. And indeed there is scarce any quality, for whose differences we have fewer distinct names, having scarce any for the many degrees of coldness, that may be conceived to be intermediate, betwixt lukewarmness and the freezing degree of cold, and even these are undefined enough; for that, which to some men's senses will feel lukewarm, by others will be judged hot, and by others, perhaps, cold; nor is even the glaciating degree of coldness well determined, since not only differing liquors, as oil, wine, and water, will manifestly freeze much more easily one than another, but even liquors of the same denomination; and of waters themselves, some are more easily turned into ice than others: and I see no great cause to doubt, but that there may be sufficiently differing degrees of cold, whereof the mildest may suffice for the congelation of some waters. I must not forget to add, that the same person, that has made many observations with a weather-glass, is so confined by that numerical instrument, that, if by the spilling of the liquor, or the cracking of the glass, or the casual intrusion of some bubbles of air, or by any of divers other accidents, that may happen, the instrument should be spoiled, he would, though he should employ again the same instrument, be reduced to seek out a new standard, wherewith to measure the varying temperature of the air. And though it be not difficult to include in the cavity of a weather-glass some other fluid body instead of air, yet it will be very difficult, if not impossible, to include a body, fit to resent and show the alterations of the ambient air, without being also liable to receive impressions from it at the time of its being first shut up.

YET I will not here omit, that I have sometimes considered, whether the essential oil of aniseeds (which is that, that is distilled by the intervention of water in a limbeck) might not, during a good part of the year, be of some use to us, in making and judging of weather-glasses. For this liquor, as we elsewhere also note, having the peculiarity of losing its fluidity during almost all the winter, and a good part of the spring, and autumn too, when the weather, or the time of the day, is colder; this liquor, I say, being such, in case you very gently thaw it, and then putting into it the ball of a weather-glass, furnished with spirit of wine, that will burn all away, you suffer the oil to re-congeal leisurely of itself, you may, by observing the station of the spirit of wine in the thermoscope, when the oil begins manifestly to curdle about it, be in some measure assisted to make another weather-glass like it*. For if you put

* An ingenious man has proposed another way of settling a standard for weather-glasses, namely, by observing the coldness, which is requisite to make distilled water begin to freeze: but though the accuracy of this way may be as well as the other justly questioned, and cannot often be put in practice, even in winter itself, nor without trouble; yet it may also be advantageously made use of, when the cold happens to be great enough to freeze water.

such rectified spirit of wine into a glass, the cavity of whose spherical, and that of its cylindrical part, are as near, as may be, equal to the correspondent cavities in the former glass, you may, by some heedful trials made with thawed and re-congealed oil of aniseeds, bring the second weather-glass to be somewhat like the first; and if you know the quantity of your spirit of wine, you may easily enough make an estimate, by the place it reaches to in the neck of the instrument, whose capacity you also know, whether it expands or contracts itself to the 40th, the 30th, or the 20th part, &c. of the bulk it was of, when the weather-glass was made. By the help of the same oil you may make some kind of estimate, though a more uncertain one, of the difference of two weather-glasses of unequal bigness: and though I know not how much may be alledged to shew the uncertainty of this way of making a standard for weather-glasses; yet as what I have formerly represented may manifest me to be far enough from looking on it as an exact standard of cold; so perhaps the way proposed may not be altogether useless in the making and comparing weather-glasses, since, in such cases, where we are not to expect to hit the mark itself, it is of some advantage to be able to shoot less wide of it, than otherwise we should.

II. BUT not to insist any further on a difficulty, which is so hardly evitable as that, which occurs about settling a perfect standard of cold, there are unaccuratenesses in the measuring of cold by weather-glasses, which may be avoided, but are not; for men are not wont to take care, that the stems be even and cylindrical enough, but are wont to make use of such, as are much wider at the upper part near the bubble, than elsewhere; nor do they observe, as they might, a proportion betwixt the diameter of the bore of the cylinder, and that of the cavity of the spherical bubble, and divers other circumstances are commonly neglected, which, if well ordered, would make much towards the certainty and instructiveness of the informations, afforded us by weather-glasses. To which may be added, that even in those, where some part of the liquor is exposed to the external air, there may be made contrivances much more convenient, in order, at least, to some particular purposes, than that of the vulgar weather-glass; some of which we have employed, and others have been either skilfully devised, or also happily attempted by some eminently ingenious members of the Royal Society. And though that, which we have already described in another treatise, be very simple, yet it is much more commodious for several of the following experiments of cold, than that, which is commonly in use. For in this, where the included air is as it were pendulous at the top of the glass, it is very troublesome and difficult so to apply cold bodies, and especially liquid ones to it, as therewith to measure their temper; whereas the thermometers, I speak of, being made by the insertion of a cylindrical pipe of glass (open at both ends) into a phial or bottle, and by exactly stopping with sealing-wax, or very close cement, the mouth of the phial, that the included air may have no communication with the external, but by the newly-mentioned pipe: in this kind of instrument, I say, by chusing a phial as large as you please, and fitting it with a cylinder, slender enough, the proportion between the part of the phial posselt by the included air, and the cavity of the cylinder, in which the liquor is to play up and down, may be easily made so great, as to make the liquor in this instrument, with the same degree of heat and cold, rise or fall four or five, or more times, as much as the pendulous liquor is wont to do in an ordinary weather-glass, where the cavity that lodges the air, is wont to be much too small, considering the bigness of the pipe, whereinto the air must, when it is rarified, expand itself. But it is not the greater sensibility (if I may so speak) of this very kind of weather-glasses, nor their not needing frames, that makes me take notice of

Dr. Wren
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Mr. Hook.

them in this place, (where I purposely pass by contrivances that I know to be more curious) but this other quality, which makes them fit for divers of the following experiments, wherein we shall have occasion to mention them; namely, that with little or no trouble and inconvenience we may employ liquors or other bodies to refrigerate the included air, by immersing the phial, if need be (by a weight) into the liquor to be examined, and letting it stand there as long as we please. And so we may also measure the coldness of earth, snow, powdered ice, and other consistent bodies, which may be heaped about the phial, or in which it may be buried.

III. I CONSIDER too, that though men are wont confidently enough to conclude, that in case (for instance) the coldness of the weather make the liquor in a thermometer yesterday an inch higher than it was the day before, and this day an inch higher than it was yesterday, the air must be this day as cold again as it was yesterday, or at least that the increase of cold must be double to what it was yesterday, and so in other proportions; yet the validity of this collection may very justly be questioned; for, though we should grant, that cold is that, which of itself, or by its own power, contracts the air, yet how does it appear, that a double degree of cold must produce a double degree of condensation in the air, and not either more or less? Since besides that it is taken for granted, but not proved, that the differing qualities of included air in several instruments, and the differing bignesses of the pipes, and the differing degrees of expansion, wherein the included air may happen to be, when the ascension of the water begins to be reckoned, may render this hypothesis very suspicious; besides all this, (I say) I am not inclined to grant, (what philosophers have hitherto supposed) that the condensation of the air, and the ascension of the water, is only, or so much as principally, collected by the proper virtue of the cold, but by the pressure of the ambient air, as we shall ere long more fully declare. And if this be made out, then the computation, we are considering, will be found to be very fallacious; for we have elsewhere shewn, *that the strengths required to compress air are in reciprocal proportion, or thereabouts, to the spaces comprehending the same portion of air.* So that if a cylinder (for instance) of four inches of air, be just able to resist a strength or pressure equivalent to ten pound weight, when it comes to be compressed into two inches; in this case, I say, an equal force superadded to the former, (which makes that a double force, or equivalent to twenty pound weight) will drive up that already-compressed air into half the space; that is, into one inch or thereabouts. Whence it follows, that in estimating the condensation of the air in a weather-glass, we must not only consider, how much space it is made to desert, but also, what proportion that deserted space bears to the whole space it formerly possessed, and to what degree of density it was reduced, before the application of the then force; and we must remember, that the resistance of the included air is not to be looked upon, as that of a weight, which may remain always the same, but that of a spring forcibly bent, and which is increased more and more, as it is crowded into less and less room. But these nicer speculations it would here be somewhat improper to pursue.

IV. WHEREFORE I shall proceed to what may seem a paradox, that even the particular nature of the liquors, employed in weather-glasses, is not altogether to be neglected, till we have a better and more determinate theory of the causes of cold, than I fear we have: for, though usually it matters not much, what liquor you employ, yet it is not impossible, that in some cases men may slip into mistakes about them; for it will not follow, that if of two liquors, the one be much the more obnoxious to the higher degree of cold, that of glaciation, the other must be less easily suscep-

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tible of the lower degrees of cold; since those, that make sealed weather-glasses, some with water, and some with spirit of wine, have confessed to me, that they find these (last named) much more apt to receive notable impressions from faint degrees of cold, than those, that are furnished but with water, which yet is easily turned into ice by the cold of our climate, which will by no means produce the like effect upon pure spirit of wine.

BESIDES, we cannot always safely conclude (as philosophers and chymists generally do) that the more subtil and spirituous liquors must be the least capable of being congealed (that is, made to lose its fluidity, as oil and some other substances are wont to be reduced to do, by the action of cold) for the chymical oil of aniseeds distilled by a limbeck is so hot and strong a liquor, that a few drops of it conveniently dissolved will make a whole cup of beer taste as strong, and, perhaps, heat the body as much as so much wine; and yet this hot and subtil liquor I have found upon trial, purposely made, to be more easily congealable (in the sense freshly explained) by cold than even common water, and to continue so several days, after a thaw had resolved the common ice into fluid water again. And I know some distilled liquors, whose component particles are so piercing and so vehemently agitated, that the tongue cannot suffer them, and that they are not perhaps inferior to most chymical oils, nor to aqua fortis it self; and yet these may be congealed by far less degrees of cold, than such, as would yet prove ineffectual to freeze either the generality of chymical oils, or the generality of saline spirits.

AND indeed, till we attain to some more determinate theory of cold, and come to know more touching its causes, than we yet do, I see not, why it should be absurd to suspect, that though there be some kind of bodies, which seem fitted to produce cold indiscriminately in the bodies they invade or touch; yet if the refrigeration of a body be but the lessening of the wonted or former agitation of its parts (from what cause soever that remissness proceeds) it seems not impossible; but that besides those bodies or corpuscles, that may be looked upon as the catholick efficient of cold, there may be particular agents, which in reference to this or that particular body may be called frigorifick; though they would not so much refrigerate another body, which perhaps would be more easily affected, than the former, by other efficient of cold. For we may observe, that quicksilver may be congealed by the steams of lead, which have not been taken notice of to have any such effect, upon any other fluid body; and yet quicksilver is not to be deprived of its fluidity by such a degree of cold, as would freeze not only water but wine. And by what we have formerly related upon the credit of that great traveller, the Jesuit *Martinius*, it seems, that water it self may in some regions be so disposed by the constitution of the soil, that it is susceptible of strange impressions of cold in proportion to the effect, which that degree of cold produces there in human bodies. Besides, opium also, of which three or four grains have too oft destroyed the heat of the whole mass of blood in a man's body, though that be a very hot, subtil, and spirituous liquor, does not sensibly refrigerate water, as far as I could observe with a good sealed weather-glass, which I put sometimes in a glass of ordinary water, and sometimes into a glass of water of the same temper, and (as we guessed) of the same quantity, wherein opium, enough to kill very many men, was put in thin slices, and suffered to dissolve; which seems to argue, that as differing liquors have each their peculiar texture, so there may be certain bodies, whose minute particles by their peculiar size, shape, and motion, may be qualified to hinder, or at least lessen, the agitation of the particles of the appropriated liquor, into whose pores they insinuate themselves; and thereby, according to the lately mentioned supposition, they may refrigerate that particular liquor, without having the like effect
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on other liquors, whose textures are differing. And I might countenance this by adding, that as fiery and agitated a spirit as that of wine, when well dephlegmed, is justly thought to be; yet I know more liquors than one, that being mingled with it, will in a trice deprive it of its fluidity; and the like change I have sometimes made in some other liquors also. But I must not insist on such matters, having mentioned them but only to awaken men's curiosity and circumspection, and not to build much upon them; which will be easily credited, if it be remembered, that a little above I my self sufficiently intimated, that this conjecture supposes something about the theory of cold, which is not yet sufficiently cleared. Only, because the former experiments shew, that the various agitation of the minute parts of a liquor, whereon its fluidity depends, may be hindered or suppressed by the intervention of adventitious corpuscles, but do not clearly shew, that the liquor by being deprived of that kind of agitation does actually acquire a coldness; I might subjoin thus much, that by the addition of a certain substance (which for just reasons I must forbear to describe) that would scarce sensibly refrigerate common water; I can make a certain (and for aught I know, one only) liquor, that is wont to the touch to be much of the temper of water, to receive a considerable degree of coldness. This, I say, (as strange as it may seem) I might here subjoin to countenance the conjectures I have been delivering, and afford some new corollaries; but for the reason newly intimated I forbear, and the rather, because I think it high time to return thither, whence the considerations, I have offered about weather-glasses, have made me digress.

I WAS going then to take notice, upon the occasion offered by what I related of the influence of the atmosphere's gravity upon common weather-glasses, of the difference between them and those that are hermetically sealed. And indeed these are in some things so much more convenient than the others, that (if I be not mistaken) it has already proved somewhat serviceable to the inquisitive, that I have directed the making of the first of them, that have been blown in *England*. At the beginning indeed I had difficulty to bring men to believe, there would be a rarefaction and condensation of a liquor hermetically sealed up, because of the school-doctrine touching the impossibility of a vacuum, and especially, because I had never seen any experiment of this kind, nor met with any that had: but after some trials, which my conjectures led me to make successfully enough, that in hermetically sealed glasses, both air and water might be alternately rarified and condensed; I found my work much facilitated by the sight of a small sealed weather-glass, newly brought by an ingenious traveller from *Florence*, where it seems some of the eminent virtuosi, that ennobled that fair city, had got the start of us in reducing sealed glasses into a convenient shape for thermoscopes. But since that, the invention has in *England* by a dexterous hand, that uses to make them for me, been improved, and the glasses we now use are more conveniently shaped, and more exact than the pattern, I caused the first to be made by. But the filling of these long ones, that we now use, is a work of more niceness and difficulty, than they, that have not tried, will be apt to imagine, and therefore may elsewhere deserve either from our pen, or his, that is most versed in making them, a more particular account of the way of performing it; the advantages of these weather-glasses being at no hand inconsiderable. For, the weight or pressure of the atmosphere (which, as we have noted, may work very much upon others) their being sealed defends them from: and by this advantage they may be used in the highest and in the deepest places, with as much certainty as any where else. Next, whereas in other thermometers the liquor is very subject to be spilt, in case they be removed from place to place, and, which is worse, though they be not removed, is subject to be

preyed upon and wasted by the air, whereby informations of such weather-glasses are rendered in tract of time somewhat uncertain; in sealed weather-glasses, there is no danger, that liquor should either spill or evaporate. And upon the same account, these have this advantage, that you may safely let them down into the sea, and immerse them in any liquor, you please, without excepting the most corrosive to examine their coldness: not to mention, that instead of the coarser liquors used in common weather-glasses, which are some of them not unapt to freeze, and others unapt enough to comply with the slighter alterations of the air, and instead of the colourless liquor, whether water or no (I know not) used in the Florentine weather-glass I saw, we employ highly rectified spirit of wine, whose being brought to a lovely red with cochineal, opened by the most subtle volatile spirit of urine, by which means the included liquor is not only very conspicuous and secured from freezing, but so susceptible of even the slighter impressions of external bodies (which would work but faintly on water) that 'tis pleasant to see, how many inches a mild degree of heat will make the tincture ascend in the very slender cylindrical stem of one of these useful instruments; of which we have spoken the more particularly in this place, because we shall have frequent occasions to mention them in the following papers; and no body as yet, that we know, has written any account of them.

BUT though these weather-glasses be much more to be relied on, than those, that are commonly in use, yet we would have a philosopher look upon both these and our sensories, but as instruments to be employed by his reason, when he makes his estimates of the coldness of bodies: and though perhaps it will signify nothing in the event, yet I see not, why it should misbecome a naturalist's diligence and circumspection, to try, whether even such weather-glasses ought to be so far allowed of, as to hinder men from looking after any other kind of ways of estimating cold.

FOR, though the sealing of these weather-glasses protect the included liquor from the pressure of the air, and keep it from evaporating, yet it will not follow from hence, that they must be exempt from all the other imperfections, which we formerly mentioned to be imputable to weather-glasses.

I KNOW not, whether you will allow me to add on this occasion, that tinted spirit of wine (and the like may, for aught we know, be said of any such liquor) being a particular mixture, in case it be allowed possible, that the subtle steams of such bodies (as we formerly noted to be frigorick in respect to some liquors) may insinuate themselves through the pores of glass; as it is granted, that the effluvioms of the loadstone do readily permeate it: in this case, I say, though I willingly allow it not to be likely, yet it is not absolutely impossible, that some steams, that wander through the air, may be more or less cold, or may more promote or hinder an agitation among the minute parts in reference to it, than in reference to other liquors: as we formerly noted, that a grain or two of opium will exceedingly allay the warmth and motion of the whole mass of blood in a man's body, though ten times that quantity will not sensibly refrigerate the tenth part of so much water. And that this may appear the less extravagant, I shall here add some mention of an odd phenomenon, that, as it were, by some fate has occurred to me, since I began the discourse I am now upon: for whilst I was yesterday writing it, I had occasion to examine by such a sealed weather-glass (as I have been speaking of) the temper of a certain strange kind of mixture, that towards the close of this treatise, I shall have occasion to take special notice of: and though to the touch it appeared but lukewarm, yet having put into it the ball, and part of the stem of the sealed weather-glass, I found the included liquor slowly enough impelled up so high, that at length, to my wonder, it rose eight or nine inches in a stem, which was not much above a foot long. But that which I
relate,

relate, as the surprizing circumstance, is, that when I had taken out the thermoscope, and removed it again into a deep glass full of cold water, whence I had just before taken it out, to put it into the anomalous mixture, I had a mind to examine; the tincture in the weather-glass did not (as it was wont, and as any one would have expected) begin to subside again towards its former station, but continued within about half an inch or less of the very top of the instrument, though neither my own busy eyes, nor those of a person very well versed in making and using thermoscopes, could perceive, that the expanded tincture was any where discontinued by any air or bubbles, which at first we suspected might possibly (though it were very unlikely) have been generated by the tepor of the mixture. But that, which continued our wonder, if not increased it, was, that during four or five hours, that the instrument continued in the cold water, and during some hours also, that it was exposed to the air, the tincture did not subside above half an inch; and, which is yet more strange, having left the glass all night in the window of a room, where there was no chimney, I found in the morning, that its descent was scarce sensibly greater, for it continued about eight inches higher than the mark it stood at, when I first put it into the lukewarm mixture; and how long it will retain this strange expansion, is more than I can tell. But by this, and what I may have occasion hereafter to relate, concerning this mixture, it may appear somewhat the more reasonable to suspect, than even sealed weather-glasses furnished with high rectified spirit of wine, may in some (though very rare) conjunctures of circumstances, and from some peculiar agents, either by their insinuating themselves through the pores of the glass, or on some other account, receive impressions, that, as far as can easily be discerned, are not purely the genuine and wonted operations of heat and cold.

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THE chymist *Orthelius* tells us, that the liquor distilled from the ore of magnesia or bismuth (which seems to be the same mineral that we, in English, call tin-glass) will swell in the glass it is kept in, not only manifestly, but very considerably at the full moon, and shrink at the new moon; and if all my endeavours to procure that ore had not proved fruitless, I should be able, by my own experience, to disprove or confirm so admirable a phænomenon: but being as yet unfurnished to make the trial myself, lest it might appear a vanity, so much as to mention (without rejecting it) a thing so very unlikely; I shall add, that since I find the thing, for the main, which was delivered by the chymist, employed as an argument by a famous mathematician (the Jesuit *Casatus* *) whose expressions are such, as if he himself had observed, that even in stopt glasses, the fore-mentioned mineral spirit increased very sensibly in bulk about the time of the full moon; which wonder being admitted, may not only countenance what we were saying, but hint some other very strange things in nature. This brings into my mind, (what I have elsewhere mentioned) that a tincture of amber I had made with high rectified spirit of wine, did, for many months, in a well-stopt glass, discover itself to be affected with certain changes, which were thought to proceed from some secret mutations of the air, that did sensibly so work, as I had not observed it to do upon other liquors, wherein the spirit of wine abounded. And, perhaps, upon

* *Vitrum optime clausum ne quid expirare posset, in loco ubi quiesceret, statui, nec sine animi voluptate licebat in plenilunio manifesta inclusi liquoris incrementa observare, in novilunio vero decrementa, &c.* They are the words of *Paulus Casatus*, in his *Terra Machinis mota*, Page 143. But since the writing of these preliminary discourses, the author of them having consulted, by the means of some ingenious friends, the learned *Casatus*, finds, that he never made or saw the experiment himself, but relates it upon the authority of a certain Dutchman, whose name he adds not, and who therefore may probably be the same *Orthelius*, that is mentioned by the author of these preliminary discourses; who thinks it requisite to give the reader this advertisement, because *Casatus* himself did not, as he should have done, intimate, that he delivered this but upon another's credit.

long and diligent observation, one might find a disparity betwixt weather-glasses kept in the same place, but furnished with differing liquors; a disparity, I say, that could not be so well ascribed to any thing, as to the peculiar nature of the respective liquors, which, though of divers kinds, may (to add towards the facilitation of trials) be made of a very conspicuous colour, by the self-same metal, copper, which not only gives the known colour in aqua fortis, but affords us a fair solution in aqua regis, and it makes a liquor of a deep and lovely blue in spirit of urine, or of sal armoniac, and the like: nay, I have found, that in good chymical oil of turpentine (for expressed oils are too easily congealed) the bare filings of it will yield a sufficient tincture. But because it is yet but a bare suspicion, that sealed weather-glasses, made of differing liquors, but in other points alike, may be otherwise uniformly affected by the temperature of the external air; I shall now add an observation already made, to shew, that even the sealed weather-glasses, furnished with spirit of wine, are not so perfectly secluded from all commerce with external bodies, and liableness to their operations, but that they may be wrought upon otherwise than we think. For I have more than once observed, that even in sealed thermoscopes (made purposely at home for me, and with great care, by the expertest maker of them) after a good while, and when no such matter was expected, there have emerged bubbles, which, whether they proceeded from some undiscernible particles of air, harboured in the pores of the water, which, in process of time, by their union, came to make conspicuous bubbles, or from some disposed particles of the spirit of wine itself, by successive alterations, brought to a state of elasticity, I now examine not; but only affirm, that sometimes I have had, of these bubbles, great enough to possess the space of many inches, in the shank of a long sealed weather-glass, and I have been troubled with them in more weather-glasses than one or two: which I therefore take notice of, not only because it serves to prove what I was saying, but because it is very fit an advertisement should be given of it to prevent mistakes. For when these bubbles are small, and are generated, or happen to stay at or about the place where the spherical and cylindrical parts of the glass meet, they may easily (as I have observed) lurk unheeded, and reaching from side to side, so divide the spirit of wine in the ball from that in the stem, that the latter shall not be able to rise and fall according to the changes of the weather; the bubble, notwithstanding its aerial nature, being more indisposed to be moved up and down in the slender stem of a small weather-glass, than the spirit of wine itself, as we have elsewhere shewn, that when air is not forced, a bubble of it will not, in several cases, so readily pass through a very narrow passage, as would that grosser fluid, water.

BUT all these difficulties (not to call them extravagancies) which I have been mentioning about sealed weather-glasses, I represent not to shew, that it is (at least as yet) worth while to suspect us so far, as to employ all the diligence and inventions, that were requisite to prevent or silence the suspicions of a sceptick, or that might be thought upon, in case the matter did require or deserve such extraordinary nicety, but only to give men a rise to consider, whether it would be amiss to take in (when occasion presents itself) as many collateral experiments and observations, as conveniently we can, to be made use of, as well as our sensories and weather-glasses, in the judications of cold. And, perhaps, an attentive enquiry, purposely made, would discover to us several other bodies, natural or factitious, which we might make some use of in estimating the degrees of cold. For though (to give an instance) water be thought to be the liquor, that is most susceptible of such an intensity of cold, as will destroy or suspend its fluidity; yet, not here to repeat what we formerly delivered of the easy congealableness of oil of aniseeds, we have (as we elsewhere note to another purpose) distilled a substance from benzoin, which becomes of a fluid, a consistent

body, and may be reduced to the state of fluidity again by very much lesser alterations of the ambient air, as to heat and cold, than would have produced ice or thawed it. I could also here take notice of what I have sometimes observed in amber-grease, dissolved in high rectified spirit of wine, or in other sulphureous or resinous concretions dissolved in the same liquor: for now and then, though it seemed a meer liquor in warm weather, it would in cold weather let go part of what it swallowed up, and afterwards re-dissolve it upon the return of warm weather; some of these concretions, as I have seen in excellent amber-grease, shooting into fine figured masses, others being more rudely congealed. And I might also add, what I have observed in chymical liquors, (not unskilfully prepared out of urine, hartshorn, &c.) which would sometimes seem to be totally clear spirits, and at other times would suffer a greater or lesser proportion of salt to crystallize at the bottom, according to the mutations of the weather, in point of cold and heat. Such kind of instances (I say) I could mention, but I shall rather chuse to prosecute my examples in that obviousset of liquors, water; and add, that even that may afford us other testimonies of the increased or lessened cold of the air, than that which it gives us in common weather-glasses. For in some parts of *France* the watermen observe, that the rivers will bear boats heavier loaded in winter, than in summer; and I have upon inquiry been credibly informed, that seamen have observed their ships to draw less water upon the coasts of frozen regions (where yet the sea is wont to be less brackish) than they do on our British seas: which argues, that water is thicker and heavier in winter than in summer. Nay, I shall add, that not only in differing seasons of the year, but even at several times of the same day, I have often observed the coldness of the air to be (regularly enough) so much greater at one time of the day than at another, that a glass bubble hermetically sealed and poised so as to be exactly of the same weight with its equal bulk of water, as that liquor was constituted at one time of the day, would about noon, when the warmth, that the summer's sun produced in the air, had somewhat rarified the water, and thereby made it, bulk for bulk, somewhat lighter than before, the bubble would sink to the bottom of the water, which (for the better marking the experiment) I kept in a glass-tube; but when at night the coolness of the air had recondensed the water, and thereby made it heavier, it began, by little and little, to buoy up the bubble, which usually by morning regained the top of the water; and at other times of the day it not unfrequently happened, that the bubble continued swimming up and down betwixt the top and the bottom, without reaching either of them, sometimes staying so long in the same part of the tube, that it much surprized divers of the virtuosi themselves, who thought the poising of weight so nicely, not only a very great difficulty (as indeed it is) but an insuperable one. But of this experiment I elsewhere say more; and because about other weather-glasses, I have said so much already, I think it may not be improper to sum up my thoughts concerning the criteria of cold, by representing the following particulars:

1. THAT by reason of the various and unheeded pre-dispositions of our bodies, the single and immediate informations of our senses are not always to be trusted.

2. THAT though common weather-glasses are useful instruments, and the informations they give us are in most cases preferable to those of our sense of touching, in regard of their not being so subject to unheeded mutations; yet even these instruments being subject to be wrought upon by the different weights of the atmosphere, as well as by heat and cold, may (upon that and perhaps some other accounts) easily misinform us in several cases, unless in such cases we observed by other instruments the present weight of the atmosphere.

3.

3. THAT

3. THAT the sealed weather-glasses, we have been mentioning, are so far preferable to the common ones, as (especially they not being obnoxious to the various pressure of the external air) that there seems no need in most cases to decline their reports, or postpone them to those of any other instruments: but yet in some nice cases it may be prudent (where it may conveniently be done) to make use also of other ways of examining the coldness of bodies, that the concurrence or variance to be met with in such ways of examination, may either confirm the testimony of the weather-glass, or excite or assist us to a further and severer inquiry.

4. THAT I would not have men too easily deterred from devising and trying various experiments (if otherwise not unlikely or irrational) about the estimating of cold, by their appearing disagreeable to the vulgar notions about that quality. For I doubt, our theory of cold is not only very imperfect, but in great part ill grounded. And I should never have ventured at trying to make sealed weather-glasses, if I could have been withheld either by the grand Peripatetick opinion, that (to shun a void) water must remain suspended in glasses, where, if it fall, the air cannot succeed it; or the general opinion even of philosophers as well new as old, that air must be far easier, than any visible liquor, condensed by cold.

DISCOURSE III.

Containing the second Paradox, *viz. Touching the Cause of the Condensation of Air, and Ascent of Water by Cold in common Weather-glasses.*

THOUGH I thought here to end the preliminary discourse, as doubting it may be thought prolix enough already, yet for confirmation of what I was lately noting, about the incompleteness of the theory of cold, (and because the evincement thereof may give rise to many trials, that may enrich the history of cold) I will here subjoin a discourse formerly written on another occasion. For though upon that account I am fain to leave out the beginning of it, as not suited to the present occasion, yet the main body of the discourse may be (I think not improperly) annexed to what has been already said about weather-glasses; since it examines the causes of the principal phenomenon of them, and will perhaps help to discover the incompleteness of men's notions about cold, by shewing, that the true cause, even of the most obvious phenomenon of common weather-glasses (though almost every man thinks he understands it) has not yet been sufficiently inquired into.

THE discourse then, that first part of it (as foreign to our present purpose) being omitted, is as follows.

—— To prosecute our disquisition satisfactorily, it will concern us to consider, upon what account the water rises in cold weather, and falls in hot, in common weather-glasses, whose construction being so well known, that we need not to spend time to set it down, we may forthwith proceed to take notice, that concerning the reason, why in these weather-glasses the water, or other liquor in the shank or pipe, ascends with cold, and descends with heat; there are three opinions, that will deserve our consideration.

THE first is the common opinion of the schools and Peripateticks, and indeed of the generality of learned men of differing sects, who teach, that the cold of the external air, contracting the air included in the weather-glass, and thereby reducing it into a

narrower room than formerly it possessed, the water must necessarily ascend to fill the place deserted by the retired air, lest that space should become a vacuum, which nature abhors.

BUT against this explication, we have several things to object.

FOR first, I am not satisfied, that any of the schoolmen or Peripateticks (at least of those I have met with) have solidly evinced, that nature cannot be brought to admit of a vacuum. Nor do I much expect to see that assertion well proved, by these, or by any other, that forbear to make use of the argument of the Cartesians drawn from the nature of a body, whose very essence they place in its having extension: which I say, because about this argument I neither have yet published, nor do now intend to deliver my thoughts.

NEXT, it seems a way of explicating, that little becomes a naturalist, to attribute to the senseless and inanimate body of water an aim at the good of the universe, strong enough to make it act, as if it were a free agent, contrary to the tendency of its own private nature, to prevent a vacuum, that, as is presumed, would be hurtful to the universe.

BUT these arguments we have elsewhere urged, and therefore need not insist longer on them here.

THIRDLY, If you take a bolt-head, with a large ball and long stem, and do, with that and quicksilver, make the Torricellian experiment, there will be an instrument prepared like a common weather-glass, save that the stem is longer, and that the liquor is mercury instead of water; and yet in this case we see not, that the mercury, which remains pendulous in the pipe at the height of about thirty inches, offers to ascend into the cavity of the bolt-head, to fill up the space, whence the air was expelled by the mercury, and which the quicksilver also by its subsiding deserted. And the outward application of cold bodies to the forsaken part of the head will not, perhaps, occasion the rising of the quicksilver $\frac{1}{4}$ of an inch, if half so much, though the like degree of cold would make the water ascend in a vulgar thermometer, though shorter, to the height of several inches. But this argument I also, on another occasion, further display and vindicate.

WHEREFORE I shall add one more, taken from the consideration of these sealed weather-glasses, that are described in this present History of Cold. For in these the air does not shrink, but rather seems to be expanded, when the weather grows colder. If it be said, that water being contracted by the cold, the air follows it, to prevent a vacuum; I answer, that those, that say this, should explain why, whereas in common weather-glasses the water ascends to follow the air, in these the air must descend to follow the water; and why, since to avoid a vacuum, the one in common weather-glasses, and the other in sealed ones, resists contraction, nature does not rather make the air in common thermometers retain the extension, they conceive due to its nature, than put her self to the double labour of suffering the air to be preternaturally condensed, and compelling the water to ascend contrary to its nature. But these arguments I will not urge so much as this other, that in our present case the above proposed answer will by no means solve the difficulty. For if the water be really condensed into less, and the air expanded into more space, than they respectively possessed before; I see not, how a vacuum or a worse inconvenience will be avoided. For I demand, since glass is granted to be impervious to air and water, (as indeed else nature would not need to make water ascend contrary to its own tendency in a common weather-glass) what becomes of the body, that was harboured in the space deserted by the water upon its condensation? which question, those that do not say any thing escaped away through the glass, or that any thing was annihilated, will not easily answer.

answer. But this is not all; for I further demand, when the air expands itself to follow the water, how by that expansion of the air, a vacuum both *coacervatum* (as the old Epicureans spoke) and *interspersum*, is avoided. For the aërial corpuscles cannot advance into this space deserted by the water, without leaving either in whole or in part the spaces they filled before; so that by this remove an aërial corpuscle only changes place, but does not adequately fill any more place than it did before. But if it be said, that the same air, without any substantial accession, may adequately fill more space at one time than at another; if this, I say, be pretended, I shall not urge, that it appears not, why it were not more easy for nature in common weather-glasses, as well as in sealed ones, to rarify the air, which they teach to be so very easily rarified and condensed, than to make the heavy body of water to ascend. For I may very well reply, that I scarce know any opinion in natural philosophy, that to me seems more unintelligible, and more worthy to be confidently rejected, than this harsh hypothesis of rarefaction. Of which I should think it injurious to so judicious a philosopher, as my Lord *Brouncker*, to endeavour here to manifest the absurdity, though I had not in another place shewn it already.

Defence
against
Linus,
chap. 3.

THE next opinion, we are to consider touching the cause of the ascension of water by cold in weather-glasses, is that of Mr. *Hobbes*, who, in the last chapter of his book *de Corpore*, sect. 12. having premised a delineation of a common weather-glass, subjoins this explication:

IN the sixth and seventh articles of the 27th chapter (where I consider the cause of cold) I have shewn, that fluid bodies are made colder by the pressure of the air, that is to say, by a constant wind, that presseth them. For the same cause it is, that the superficies of the water is pressed at F, and having no place, to which it may retire from this pressure, besides the cavity of the cylinder between H and E, it is therefore necessarily forced thither by the cold, and consequently it ascendeth more or less, according as the cold is more or less increased. And again, as the heat is more intense, or the cold more remiss, the same water will be depressed more or less by its own gravity, that is to say, by the cause of gravity above explicated.

BUT however the author of this explication, to prepare us to receive it, tells us, that however the above-mentioned phenomena be certainly known to be true by experience, the cause nevertheless has not been discovered; yet I confess, I think this newly recited assertion might as well have been placed after his explication, as just before it.

FOR first, whereas he remits us to the sixth and seventh articles of the 27th chapter (for the reference is misprinted) as containing the grounds of this explication, I must profess my self far from being satisfied with the general theory of cold delivered in that chapter, as being partly precarious, partly insufficient, and partly scarce intelligible, as I shall elsewhere have occasion to shew. And as for what he particularly alledges in the sixth and seventh articles of a constant wind, that presses fluid bodies, and makes them cold, besides that that is prooflessly affirmed, we shall anon have occasion to mention an experiment, where water was not only much refrigerated, but turned into ice, though it were sealed up in glass vessels, and those suspended too in other glasses; wherein some of them had air about them, and some others were totally immersed in unfreezing liquors; so that the water, that was sealed up, was sufficiently protected from being raked by the wind, as Mr. *Hobbes* conceit of the cause of freezing requires.

SECONDLY, I see no necessity, that the cold should press up the superficies of the water into the flank of the weather-glass, especially since it is manifest, that the water will

will rise with cold in a weather-glass kept in a still place, and free from any sensible wind. Besides that it should be proved, and not barely affirmed, that an insensible motion deserves the name of wind, and that such a one is the cause of the refrigeration of water; and it should be also shewn, how this wind comes to be able to raise the water, and that to the height of many inches more in one part of the superficies than in another. Besides all this, I say, we find by experience, that water poured into a bolt-head, till it have filled the ball, and reached a good way into the stem, will, upon a powerful refrigeration, short of freezing, (which is the case of water in weather-glasses, when the air grows colder) manifestly shrink into a narrower room, instead of being impelled up higher in the pipe. And if in an ordinary weather-glass, with a long shank, you apply a mixture of ice or snow, and salt to the bolt-head, the water will readily ascend in the shank to the height of divers inches, which, how it will be explained by Mr. *Hobbes's* hypothesis, I do not well see.

SECT. II.
of the same
30th chap-
ter.

THIRDLY, I wonder he should tell us, that the reason, why the pressed water ascends into the shank of the weather-glass, is, because it hath no other place, into which it may retire from the pressure of the wind; since he, rejecting a vacuum, and affirming the world to be every where perfectly full, should not, methinks, have so soon forgotten, that in the very paragraph or section immediately preceding this, himself had told us, that he *cannot imagine how the same place can be always full, and nevertheless contain sometimes a greater, sometimes a less quantity of matter; that is to say, that it can be fuller than full.* So that I see not, why the water should find more room to entertain it, in the cylindrical cavity of the weather-glass already adequately filled with air, than other where. And in the sealed weather-glasses we have above been mentioning, and wherein the water descends with cold, it will be very hard for Mr. *Hobbes* to make out the phænomenon according to his doctrine. Besides that his explication gives us no account of the condensation of the air by cold in such weather-glasses, as those, wherein the water descends with cold and rises with heat.

FOURTHLY and lastly, whereas Mr. *Hobbes* takes notice of no other cause of the depression of water in weather-glasses by heat, but its own gravity, he seems to have but slightly considered the matter. For though, in some cases, the gravity of the water may suffice to depress it, yet, in other cases, that gravity alone will by no means serve the turn, but we must have recourse to the expansive motion or spring of the air included in the cavity of the glass. For if you place a thermometer with a large ball, wherein the water ascends but a little way into the shank, in a window exposed to the warm sun, you will often perceive the surface of the water in the pipe to be a good deal lower than that of the water on the outside of the pipe; which shews, that this depression proceeds not from the bare sinking of the water, but from its being thrust down by the pressure of the incumbent air; since the water's own weight would make the internal water fall but to a level with the surface of the external water, and not so much beneath it. And for further proof, you may, by keeping such a weather-glass long enough in the hot sun, bring the air so far to expand itself, as to drive the water out of the shank, and break through the external water in divers conspicuous bubbles, after whose eruption the remaining air being again refrigerated by the removal of the weather-glass into a cooler place, the loss of that part of the air, that escaped away in bubbles, will make the water ascend higher in the shank, than in the like degree of cold it would formerly have been impelled. And thus much may suffice to shew the unsatisfactoriness of Mr. *Hobbes's* conceit.

THE third and last opinion we shall mention, is that of some ingenious modern naturalists, who acknowledging, that the air has a weight, (which Mr. *Hobbes* also does in effect admit, though he make not so good use of it as they) do by that explicate the ascension of water in weather-glasses; teaching, that the cold of the ambient air making the included air shrink into far less room than it possessed before, the water in the subjacent vessel is, by the weight of the incumbent air, which presses on it more forcibly in all the other parts of its surface, than it is pressed up in that included in the shank, impelled up into that part of the shank, which was newly deserted by the self-contracting air.

BUT though this account be preferable by far to those, which we mentioned before it, and though it be not only ingenious, but, as far as it reaches, true; yet to me I confess it seems not sufficient, and therefore I would supply what is defective, by taking in the pressure (and in some cases the spring) of the external air, not only against the surface of water, (for that the newly mentioned explication likewise does) but also against the internal or included air. For the recited hypothesis gives indeed a rational account, why the water is impelled into the place deserted by the air; but then supposes, that the air is made to contract it self by cold alone, when it makes room for the water, that succeeds in its place; whereas I am apt to think, that both the effects may proceed, at least in great part, from the same cause, and that the pressure of the contiguous and neighbouring air does, according to my conjecture, eminently concur to reduce the cooled air, shut up in the weather-glass, into a narrower space. This it does in common weather-glasses, because the ambient air retains the whole pressure it has, upon the account of its weight; whereas the internal air, by its refrigeration, even when but equal to that of the external air, loses part of the pressure it had upon the accounts of its weakened spring.

BUT this, as I newly intimated, is not the sole account, upon which the air may in some sorts of weather-glasses impel up the water, and contribute to the condensation of the air incumbent on the water. For in some circumstances (one or two of which we shall produce by and by) it may so happen, that the rest of the air, that bears up the water to be raised, will not be so much refrigerated, as the included air, that is to be condensed; and consequently the other air will have a stronger spring, than this last mentioned air will retain, and therefore the former will have a greater pressure, than the latter will be able to resist.

WE shall not now examine, whether the spring of the air depend upon the springy structure of each aerial corpuscle, as the spring of wool does upon the texture of the particular hairs it consists of, or upon the agitation of some interfluent subtil matter, that, in its passage through the aerial particles, whirries each of them about, or upon both these causes together, or upon some other differing from either of them: but this seems probable enough, that as, when air, being sealed up in a glass, is afterwards well heated, though it acquire not any greater dimensions, as to sense, than it had before, yet it has its spring much increased by the heat; as may appear, if the sealed tip be broken under water, by the eruption of bubbles, by the endeavour of the imprisoned air to expand itself: so upon the refrigeration of the air, so sealed up, though the additional spring (if I may so speak) which the heat gave it, will be lost upon the recess of that heat, or as soon as the effect of that heat is destroyed, yet there will remain, in the included air, a considerable spring, and sufficient to make it as well fill (at least as to sense) the cavity of the sealed glass, as it did when its spring was stronger. And proportionally we may conceive, that though cold, at least such as we meet with in this climate of ours, does make the spring of an included parcel of air weaker than it was before the refrigeration of that air, yet it may

may not make it so much weaker, but that the aërial corpuscles may be kept so far extended, as not at all (or scarce sensibly) to quit the room they possessed before, in case there be not, contiguous to them, any other body, which, by its pressure, endeavours to thrust them inwards, and so make them desert part of that space. Which clause I therefore add, because, that if the case proposed do happen, it is obvious to conceive, that the weakened spring of the air cannot retain so much force to resist an external pressure, as it would have, if the cold had not debilitated it; and consequently this cooled air must yield and suffer itself to be condensed, if it come to be exposed to a pressure, to which it was but equal before its being weakened. And such in common weather-glasses is the pressure, that is constantly upon the surface of the water without the pipe, upon the account of the gravity of as much of the air or atmosphere as comes to bear upon it.

HAVING thus explained our conjecture, we will now proceed to the experiments we made to countenance it, as we find them entered in our loose notes.

IN one of which, I find what follows:

WE took a phial capable of containing five or six ounces of water, and having filled it almost half full with that liquor, we inverted into it a glass-pipe of about ten inches long, and much bigger than a large swan's quill, sealed at one end, and at the other filled top-full with water; so that the open orifice being immersed under the vessel'd water (of the phial) there remained no air at the top of the pipe. Then, as much of the orifice of the phial's neck, as was not filled by the pipe, being carefully closed with cement, that no air could get in or out, the phial was placed in snow and salt, till the vessel'd water began to freeze at the top and bottom; and, according to our expectation, we found, that, notwithstanding this great degree of infrigeration of the air in the phial, the water in the pipe did not at all descend: so that either the air did not shrink by so great a cold, or the water, whether to avoid a vacuum, or otherwise, did not remove out of the pipe to possess the place deserted by the refrigerated air.

AFTERWARDS we endeavoured to repeat the experiment with the same glasses; but having had occasion to be absent a little too long (though not very long) we found, at our return, the upper and sealed part of the pipe beaten out, which we supposed to have been done by the intumescence of the water in the phial upon its glaciation.

WHEREFORE we fastened into the same phial another pipe, some inches longer than the former, and drawn very slender at the sealed end, that it might easily be broken there; and having set the phial to freeze, as before, without finding the water to descend in the pipe, we did, with a forceps, break off the sealed end, that the outward air might come to press upon the suspended water, and, by it, upon the cooled air in the phial; whereupon, as we expected, the water was swiftly depressed, by our estimate, eight or ten inches, but not so low by a pretty deal, as the surface of the water in the phial.

AFTER this, by rarifying the air in the vial, and by blowing into it through the pipe, the water was raised within about half an inch of the top of the pipe, whose slender end being sealed, the phial was again placed in snow and salt; but the spring of the air at the top, which was rarified before, was, by refrigeration, so weakened, that it was unable sensibly to depress the water; wherefore, breaking off the apex, as before, the upper air immediately drove it down divers inches.

Our last trial therefore was, to leave in the same pipe about 3 $\frac{1}{2}$ inches of air rarified as little as we could, and placing the phial in salt and snow, as before, we observed, that the air in the pipe did, upon the refrigeration of the air in the phial, expand itself very little, though the water in the phial were in part turned into ice; but upon breaking off the slender sealed end, the outward air presently depressed the water above two inches beneath the last level, and by removing the glass into a warmer room, we found, that the water ascended a pretty deal above an inch higher than the same uppermost level, whereby we probably concluded our weather-glass to be stanch.

Thus much I find together in one place, among my promiscuous collections: but after this, coming to have the conveniency of glasses so shaped as to be easily sealed, I judged it fit to make use of some of them, to keep even the most suspicious from objecting, that I should also have made some trials with glasses, which being hermetically sealed, would be sure most accurately to hinder all immediate intercourse betwixt the internal and external air. And I remember, that once we took a glass, like the bolt-head of a common weather-glass, save that the small end was drawn very slender, for the more easy breaking of the apex: and into this glass a convenient quantity of water was poured, and then the glass being sealed up at the sharp end and inverted, the water fell down to that end, and posselt its due space in the pipe. Then the round end of the glass having a mixture of snow and salt applied about it, though the internal must needs have been thereby much refrigerated, (as will be readily granted, and may be gathered from divers of the experiments mentioned in these papers) yet we observed not the water manifestly to rise. And though an attentive eye should in such a trial discern some sensible intumescence in the water; yet that may well enough proceed from some little expansion of the aerial particles, which we have elsewhere shewn to be usually latent in common water, upon the diminution of the pressure of the air above the water, caused by weakening that air's spring by the cold. But when we had, to compleat the experiment, broken the slender end of the glass under water, the included air, becoming then contiguous to that had obtained immediate intercourse with that water, whose surface was every where prest by a pillar of the external air that leaned upon it, the water was by the gravity of that outward air hastily impelled into the cavity of the pipe (the spring of whose air was, as we said, weakened by the cold) to the height, if I misremember not, of several inches.

ANOTHER sort of trial I remember we made after the following manner: We took glass-bubbles (blown with a lamp) some of about the bigness of a nutmeg, and some much greater; each of these bubbles we furnished with a very slender stem (often no bigger than a raven's quill) which was usually divers, and sometimes many inches long. Into this stem a drop or two of water being conveyed, might easily enough, by reason of the lightness of so little liquor, together with the slenderness of the cavity (which permitted not the included air to penetrate the water at the sides, but rather impel up the intire body of it) be kept suspended, and so betray very small changes, (and much smaller than to be taken notice of by common weather-glasses) as to rarification and condensation in the air it leaned upon. Now when in one of these instruments, if watching when the pendulous water was somewhat near the top of the stem, we nimbly applied to the orifice of that stem the flame of a candle, we could by that heat almost in a moment seal it up, by reason of the thinness of the glass, and the slenderness of the stem. And if then we placed the thus sealed glass in a mixture of snow and salt, how much soever the air within the cavity of the ball must be, in all probability, refrigerated by this operation, yet it would scarce sensibly,

See more concerning these weather-glasses in the first of these three discourses.

and not at all considerably shrink; as we gathered from the pendulous waters remaining in the same place, or its falling at most but inconsiderably lower. But if then with a pair of scissars or otherwise, we dextrously broke off the sealed end of the stem, and thereby exposed the internal refrigerated, to the pressure of the external air, the water immediately would be hastily thrust down, sometimes divers inches below its former station, and sometimes quite into the cavity of the round end of the glass. To which we shall add, that not only, when these thermometers were sealed, neither the usual degrees of cold, nor those of the heat in the ambient air would at all considerably depress or raise the pendulous water, which, if the glass were not sealed, would, as we formerly noted, shew it self wonderfully sensible of the mutations of the air, as to those two qualities: But we sometime purposely tried, that though upon the refrigeration of the formerly rarified air in the glass, the pendulous water were descending fast enough, yet if even then we nimbly sealed up the open orifice of the stem (which may easily be done in a trice) the descent of the water would be presently stopt, and it would stay either just in, or very near the same part of the shank, wherein it chanced to be, when by sealing of the glass it came to be fenced from the pressure of the atmosphere; and in that place it would continue till the sealed end were broken off. For then in case the ambient air were as cool, as it was when the glass was sealed, the water would for the reason already given be further depressed, according as the weakened spring of the inward rarified air was more or less remote from an equality to the pressure of the ambient air.

BESIDES, for further trial, we took a large glass-egg with a long stem, which stem was purposely so bent, that it represented a glass-siphon, in whose shorter leg the glass was drawn very small, that it might be the more easily first sealed, and then broken.

See the figure among the rest of the schemes.

THIS done, we got in a convenient quantity of water, which ascended to a pretty height in both the legs of the bent glass, after which the shorter leg being nimbly sealed after the manner hereafter to be mentioned, there remained a pretty quantity of air above the water in that shorter leg, which was purposely left there, that it might, by its spring, impel up the water in the longer leg upon the refrigeration of the air included in that longer leg. All this being done, the whole glass was so placed in a convenient frame, that the oval part of it was supported by the frame, beneath which the bended shank of the weather-glass did hang so, that a mixture of ice and salt might be conveniently laid upon this frame to surround and refrigerate the air included in the egg, without much cooling the air in the cylindrical part of the glass. The account, that I find of this trial in one of my notes, is this.

IN the greater bent egg, that was sealed up with water, in both legs, upon the application of ice and salt to the ellipsis at a convenient time, the water in a longer leg ascended a little, but not by our guess above a barley-corn's length, if near so much, and about four inches of air (as I remember) that were left in the shorter leg, expanded itself (to sense) as much; but as soon as I broke off the slender wire, wherein the shorter leg ended, the external air rushing in made the water rise about two inches and a quarter in the longer leg, and then, there not being water enough, broke through it in many bubbles.

THUS far the note, to which I shall only add, that in this case the ascension of the water in the longer leg cannot be attributed to the weight of the air in the shorter leg, that being, I know not how much, too small to lift up so much water, but to the spring of that air: and also that we need not marvel, the expansion of that air should be so small, since some of the experiments, hereafter to be related, will shew us, that

the refrigeration of the air in such trials (as that newly recited) does not weaken the spring of it any thing near so considerably as one would expect. So that the air in the longer leg could yield but a very little to that in the shorter leg, especially since the smallness of this last named proportion of air made its spring to be more easily and considerably weakened by a small expansion.

THUS far our paradoxical discourse, which contains divers particulars, that, being added to the considerations, whereunto we have (by way of appendix) subjoined it, might afford us several reflections: but having dwelt too long on one subject already, we shall now conclude with this, upon the whole matter;

THAT there is somewhat or other in the business of weather-glasses, which (I fear) we do not yet sufficiently understand, and which yet, I hope, that by other trials and more heedful observations we shall discover.

The Paper, that was prefixed (by way of a short prefatory Address) to the ensuing History of Cold, when being to be brought in, and presented to the Royal Society, it was put into the hands of its most worthy President, the Lord Viscount Brouncker, was as followeth.

My Lord,

Little Chelsea, Feb. 14, 1662. S. A.

THE time your lordship and the society appointed me for the bringing in of my papers, concerning cold, is so very short, that to give you the fruits of my obedience as early as you are pleased to require them, I must present them you very immature, and I should say very unfit for your perusal, if you were not as well qualified to supply deficiencies and imperfections as to discern them. For of all the old observations, I made divers years ago, in order to the history of cold, I have not yet found enough, to fill up one sheet of paper: and as for those, I made the last frosty season, besides that I was several times diverted by avocations distracting enough, the sharpness of the weather, which gave me the opportunity of making some experiments, brought me an indisposition, which by forbidding me to be often, and stay long in the cold air, hindered me from making divers others; and (which is worst of all) whilst I was confined to a place, where I wanted divers glasses, and other instruments I would have employed, the ways both by land and water were so obstructed by the snow and ice, that I could not seasonably procure them from London, and was thereby reduced to leave several trials, I should have made, either unattempted, or unperfected. But lest you should think, that what I intend only to excuse my unaccurateness, is meant to excuse my pains, I shall without further apology apply my self to do what the shortness of the time will allow me, which is little more, than to transcribe into this historical collection most of the particulars, which your lordship's commands exact, though haste will make me do it in the very words, for the most part, that I find them, in a kind of note-book, wherein I had thrown them for my own private use; which I the less scruple now to do, not only because the haste, that exacts from me this way of writing, may serve to excuse it in me, but that it may the better appear, how little I had designed to wrest or byass them to any pre-conceived hypothesis.

THE
EXPERIMENTAL HISTORY OF COLD BEGUN.

TITLE I.

Experiments touching bodies capable of freezing others.

TO go methodically to work, we should, perhaps, begin with considering, what subjects are capable, or not capable of harbouring the quality we are to treat of; and to invite us to this, it seems probable enough, that among the bodies, we are conversant with here below, there is scarce any except fire, that is not, at some time or other, susceptible of actual cold (at least as to sense). And even concerning fire it self, till that difficulty be clearly determined, which we have elsewhere started; namely, whether fire be not, as wind, (at least like such as is made by air blown out of a pair of bellows) rather a state of matter, or matter considered whilst it is in such a kind of motion, than a distinct and particular species of natural bodies, there may remain some doubt; since we see, that bodies, which may be either in a moment, as gunpowder, or (as far as sense can judge) totally, as high rectified spirit of wine, turned into fire, may yet immediately before their accension, be actually cold: and as to gunpowder, presently after accension, its scattered parts caught in closed vessels will also appear cold to the touch. But such things nevertheless we must not now insist on, partly because it requires the resolving of a somewhat difficult question, which more properly belongs to the considerations about heat, where we have already handled it; partly because our design in the following collections was not so much to gather and set down observations, that were obvious to any, that was furnished with a mediocrity of attention, as experiments purposely made in order to the history of cold; and partly too, because in this collection, though we do, as occasion serves, take notice of experiments and phænomena, that relate to cold in general, or indefinitely; yet our chief work has been to find out, and deliver, the phænomena of congelation, or of that intense degree of cold, which either does freeze the bodies it works upon, or at least were capable of turning common water, fitly exposed to it, into ice. And this may serve for a general advertisement about the ensuing papers; and consequently having premised it, we shall without any further preamble proceed to the setting down such things, as we have tried and observed concerning those matters; beginning with those, that belong to the title prefixed to the first part, or section, of our history.

1. THE bodies, that are cold enough to freeze others, are in this climate of ours but very few, and among the most remarkable is a mixture of snow and salt, which, though little known, and less used here in *England*, is in *Italy* and some other regions much employed, especially to cool drinks and fruits, which men may easily do, by burying, in this mixture, glasses, or other convenient vessels, filled either solely with wine, or other drinks, or else with water, that hath immersed in it the fruits to be refrigerated.

2. THE circumstances we are wont to observe in making and employing this mixture, we shall hereafter in due place deliver; and therefore here we shall only take notice, that we could not find upon some trials, that such glasses filled with water, as would be frozen easily enough by this mixture of snow and salt, would be in like manner frozen, in case we employed snow alone, without mingling any salt with it. I deny not, that it is very possible, that in very cold countries, as well snow as beaten ice

ice may freeze water poured into the intervals of its parts. But there is great odds betwixt water so intermingled with ice or snow, and only surrounded with it in a vessel, where the water is, as it were, in one intire body, and of a comparatively considerable thickness: and there is also a great difference betwixt the degrees of coldness in the air of frigid regions, and of *England*. And perhaps too there may be some disparity betwixt the degrees of coldness of ice and snow in those climates, and in ours. And we must have a care, that in case a phial full of water buried all night should freeze, we ascribe not the effect to the bare operation of the snow, which may be (entirely, or in great part) due to the coldness of the air, which would, perhaps, have performed the effect without the snow.

3. BUT though snow and salt mixt together will freeze water better than snow alone, yet we must not think, that there is any such peculiar virtue in sea-salt, to enable snow to freeze, but that there are divers other salts, each of which concurring with snow is capable of producing the like effect. For we found upon trial, that we could freeze water without the help of sea-salt, by substituting in its place, either nitre, or alum, or vitriol, or sal armoniac, or even sugar; for either of those being mingled with a due proportion of snow, would serve the turn, though they did not seem equally to advance the congealing power of the snow; nor scarce any of them did do it so well as sea-salt. But of this elsewhere more.

4. WHEN we had made the newly-mentioned trials, some particular conjectures, we have long had about the nature of salts, invited us to try, whether, notwithstanding the comminution and consequent change produced in salts by distillation, the saline corpuscles, that abound in the distilled liquors of those concretes, as well as in their solutions, would not likewise, by being mixt with it, enable snow to freeze water, at least in small and slender glasses? This we first went about to try with good spirit of salt: but we found, as we feared, that though it made a sufficiently quick dissolution of the snow it wrought upon, yet its fluidity hindered it from being retained long enough by the snow, to the bottom of which it would fall, before they had stayed so long together, as was requisite to freeze so much as a little essence-bottle full of common water.

5. WHEREFORE we bethought our selves of an expedient, whereby to try the operation, not only of those spirits, but of divers other bodies, which were unapt for a due commixture of snow after the way newly mentioned, or of which we had too little, or valued them too much, to be willing to spend quantities of them upon these trials. And this way (that remains to be mentioned) we somewhat better liked, because the experiments made according to it would also prove experiments of the transmission of cold through the extremely close body of glass.

AND even in this way of trying, we did at first meet with a discouragement, which, lest it should happen to others, we shall here take notice of; namely, that having put a convenient quantity of snow into a somewhat thick green glass phial, though we copiously enough mixt with it a somewhat weak spirit of salt, (being loth to employ the best we had) and having well stopt the vessel, did carefully shake together, and thereby agitate the mixture in it, yet the glass appeared only bedewed upon the outside, without having there any thing frozen. But suspecting, that the thickness of the glass might be that, which hindered the operation of the included mixture, we put snow and a convenient proportion of the self-same spirit of salt into a couple of thin phials, one of which we closed exactly, and the other negligently, and having long shaken them, we found, that what adhered to them on the outside, was (though but somewhat faintly and thinly) frozen.

6. AND,

6. AND, as to this sort of experiments, we shall here observe once for all, that the snow or ice included, together with the saline ingredient (whatever that were) was always thawed within the glass; and that consequently, it was the condensed vapour of the air, or other liquor that adhered to the outside of the glass, which was turned into ice, which is the reason, why in mentioning these experiments we often use the word freeze in a transitive sense, to signify the operation of the frigorifick mixture upon other bodies.

7. THIS premised, let us proceed to relate, that we afterwards took oil of vitriol, and mixing it with snow in such another phial as that last mentioned, we found its freezing power far greater than that of spirit of salt. And lest it should be pretended, that in these experiments the cold was not transmitted through the sides of the glass, but that the air within the phial, highly refrigerated by the mixture, did upon the account of their free intercourse enable the air contiguous to the outside of the phial to freeze the dew it met with sticking on it; we prosecuted the experiments with the addition of this circumstance, that on several occasions we sealed up the phial, that contained the snow and the other frigorifick body it was mixed with, and afterwards by the help of this mixture froze the externally adhering moisture.

8. HAVING then, according to this way, substituted spirit of nitre for oil of vitriol, or spirit of salt, we found, that it froze yet more powerfully than either of those two liquors, and continued to do so in those parts of the outsides of the glass, that were adjacent to the included snow, till that snow was almost totally resolved into a liquor. This we tried both in a thin sealed glass, and in a pretty thick glass stopped only with a cork.

9. AFTERWARDS we successfully enough tried the experiment with spirits less acid, as not only with spirit of vinegar, but with spirit of sugar; I mean the red empyreumatical spirit forced over in a retort, which mixed with snow, according to the manner of the experiment, did at length freeze the externally adhering moisture. But the films of ice were very thin, and very apt quickly to disappear.

10. HAVING thus made a number of trials with acid spirits, we thought fit to make some with urinous spirits, that abound in volatile salt; and accordingly having mixed spirit of urine and snow in an open phial, and agitated them, we found, that the external moisture did discernably, though not very strongly, freeze.

BUT with spirit of sal armoniac drawn from quick-lime (according to the way I have delivered in another treatise) the operation was quick and powerful enough.

11. HAVING tried to freeze water with acid, and with volatile spirits apart, we thought it not amiss to try what they would do both together; and accordingly pouring upon snow both some spirit of urine, and a little oil of vitriol, and shaking them into the snow in an open phial, we found, that the mixture did freeze, though the glaciation, in this case produced, were very languid.

12. HAVING thus tried salts disengaged from their grosser parts, or shattered into corpuscles by distillation, we made some trial likewise with grosser salts, as with sal-gem, with a sublimate made with common sublimate and sal armoniac, nay, and with both loaf and kitchen sugar, with all which, among the like bodies, that I can now remember, the experiment succeeded well enough: also a very strong solution of pot-ashes, mixed with snow in an open single phial, did freeze, but that very faintly. And both a very strong solution of very pure salt of tartar, and (at another time) a strong solution of pot-ashes, being the one as well as the other, mixed and agitated with snow in a single phial, produced films of ice (though thin ones) on the outside of the glass.

13. AFTER

13. AFTER this, we thought fit to make a trial of another kind, of which I find this account among my notes. We filled a single phial with snow, and then poured into it a convenient proportion of a strongly sweet solution of minium in spirit of vinegar, and having shaken the mixture together, we found, that this sweet sugar of lead did, as well as acid and alcalizate salts, excite the cold of the snow so much, as to produce films of ice on the outside of the glass: but a parcel of the same solution, being for divers hours kept in snow and salt, was not thereby frozen.

In order to the discovery of some hints of the account, upon which the above-mentioned mixtures were more intensely frigefactive than snow alone, we sealed up a single phial full of snow unmingled with any other ingredient, and found it to thaw much more slowly, than any of those parcels of snow, which we had mixt with salts or spirits.

In prosecution of this conjecture, we shall add, that, for aught we could find, by divers trials, no salt, that helps not the snow to dissolve faster than else it would, did enable it to produce ice, though usually it did produce dew on the outside of the phial, that contained the mixture; and accordingly, neither crystals of tartar, nor borax, both beaten to powder, nor, which is more, (considering what we lately noted of the effects of another sort of sublimate) would sublimate enable the snow to freeze; as well the powder of sublimate as that of borax, and that of tartar, lying for a great while in the snow undissolved.

14. BELONGING to this matter, I find among my papers also this note.

[WATER of quick-lime (made by quenching store of unslacked lime in common water) twice tried, would not make snow freeze, perhaps because though the water were kept stopt, yet the liquor having been kept in the glass a twelve-month, and more; probably the spirits may have flown away, which I find, by inquiring of one that drinks much lime-water, that it abounds with, when fresh, and grows destitute of a while after: and possibly also the badness of the lime was the cause, why being mingled with snow it would not freeze, though all the phials, that did not freeze, did yet gather store of dew on the outsides (perhaps because of the snow, whose melting alone may suffice to produce that effect.)]

15. IT may seem somewhat more strange, that distilled oil of turpentine, which is so hot and fiery a liquor, should not enable snow to freeze; but this agrees not ill with the conjecture lately mentioned, for it will hereafter appear, that in oil of turpentine ice dissolves slower than in divers other liquors, without excepting common water itself.

16. AND yet notwithstanding the bad success of this trial, we were not discouraged from making another with spirit of wine; for though, according to the common opinion of chymists and physicians, it be a meer vegetable sulphur, yet we, that have elsewhere ventured to ascribe some such operations to it as chymists would have belong to saline liquors, did not scruple to seal up, in a single phial almost filled with snow, a convenient quantity of the pure spirit of wine, (drawn off from quick-lime, the better to dephlegm it) and of this mixture we found the operation more powerful than any of those we have formerly mentioned: for the freezing virtue of this did not only last long, both in the sealed single phial, and in another that was open, but the inclosed mixture presently crusted the outside of the glass (or of the neck, if it were made to fill that) with ice, which might be taken off in flakes of good breadth, or in pieces of good thickness. Nay, it presently froze urine into figured ice, which might be taken off in scales.

17. THIS last circumstance puts me in mind of another experiment, whereby we tried by a vigorous mixture of snow, and some choice spirit of nitre, we had met with, to freeze liquors of more difficult congelation than fair water.

WE took then some snow, and mingled with it some of the newly mentioned spirit of nitre in so lucky a proportion, that it froze very vigorously and very suddenly; inasmuch, that once almost as soon as it was set to the ground, it froze the phial to the floor it was set on, and the outside of the glass, that contained this mixture, we wetted with spirit of vinegar, which was frozen into pretty thick ice, but yet (not quite to forget that circumstance) retaining the salt taste of spirit of vinegar. And though this mixture would not discernibly freeze spirit of nitre on the outside, yet it transmitted cold enough to freeze weak spirit of salt, and to give us the pleasure of seeing some saline liquors presently turned into figured ice; as not only the last mentioned spirit exhibited some little (as it were) saline icicles crossing each other, and quickly vanishing, but (which was far prettier) having often observed, that sal armoniack being dissolved in water, and the solution being put very slowly to evaporate part, but not too much, away, the remaining liquor would, in the cold, shoot into parcels of salt very prettily figured, some of them resembling combs with teeth on both sides, and others resembling feathers: having observed this, I say, and being desirous to try, whether the spirit of sal armoniack, distilled by the help of quick-lime, being put to congeal on the outside of a glass, would not afford a resemblingly figured ice; we found upon trial, both that the mixture was able to freeze that subtle spirit, and also, that it shot into branches almost like those, exhibited by such salts undistilled. And it was not unpleasant to behold, how upon inclining the glass so, that the freezing mixture rested a little, near any part of the spirit, this liquor would shoot into such branches as we have been speaking of, so nimbly, that the eye could plainly discern them, as it were, to grow, and hastily overspread the surface of the glass, but those branches were wont quickly to vanish.

I HAD almost forgot to mention, that I tried the freezing with snow, and divers fermented liquors undistilled, instead of spirit of wine; and though the experiments succeeded not with small beer, much less with water, yet there was a glaciation, though but slight, produced not only by the addition of wine, but even by that of moderately strong ale.

18. HAVING observed, that the liquors and other bodies, that assisted the snow to freeze, were generally such as hastened its dissolution, we thought it not altogether unworthy the trial, to examine, what would be the event of procuring a speedy dissolution of the snow, by substituting bodies actually warm, instead of potential hot ones: of this sort of trials, I find among my notes these two registred.

[1. INTO a single phial almost filled with snow, there was poured a pretty quantity of well-heated sand, that it might dissolve the snow in many places at once, without heating the ambient air, or the outside of the glass: but though the solution of the snow seemed to succeed well enough upon the shaking of the vessel, yet the outside of the glass was only bedewed, not frozen.

2. INTO another single phial almost filled with snow, we poured some water, which we judged of a convenient warmth, and we poured it in by a funnel, that had but a slender orifice beneath, that the warm water might fall into the middle of the snow, without running to the sides; and taking a convenient time to shake the glass, we did by this way produce a very considerable degree of cold, and much dew on the outside, but were not satisfied, that any of that dew was frozen, though the success would have invited us to have made further trials in greater glasses, if we had had any more snow at hand.]

WHEREFORE this experiment is to be further and more artificially tried.

19. It is a common tradition, not only among the vulgar, but (I presume, upon their account) among learned men, that the oftentimes variously, and sometimes prettily enough figured hoar frost, which is wont to appear upon glass windows in mornings, preceded by frosty nights, are exsudations, as it were, that penetrating the glass windows, are, upon their coming forth to the cold external air, frozen thereby into variously-figured ice. How groundless this conceit is, may be easily discovered, if men had not so lazy a curiosity, as not to try (which they may do in a moment, and without trouble) whether the ice be, according to the tradition, on the outside of the window, and not contrary to it on the inside, where indeed it is generated of the aqueous corpuscles, that swimming up and down in the air within the room, are by the various motion, that belongs to the fluid bodies as such, brought to pass along the window, and there by the vehement cold of the neighbouring external air, communicated through the glass, condensed into dew, and frozen into ice.

20. AND because divers modern naturalists have taught (I think erroneously) that glass is easily enough pervious, not only to air, but to divers subtle liquors, lest the favourers of this doctrine should object, that we have ill assigned the natural cause of the ice appearing on the outside of the glass in the former experiments, which, according to them, may rather proceed from the subtler (but yet visible) parts of the excessively cold mixture of the snow and saline bodies penetrating the pores of the glass, and settling on the outside of it: to obviate this objection, I say, and to confirm what we have taught in another treatise about the wandering of store of aqueous vapours through the air, we will add the following experiments, purposely made to evince these truths.

21. AT one time four ounces and a quarter of a mixture of ice and salt, being inclosed in a phial, and thereby enabled to condense the vapours of the ambient air, was by their accession increased 12 grains.

ANOTHER time a phial, wherein snow (weighing two ounces six drachms and an half) was suffered to condense the vapid air, the dew, that partly adhered to it, and partly fell from it, made the whole weigh four grains more than the phial did, when it was first put into the scale; in which scale we found some water flowing from the dew, which gave that increase of weight. And here let me add by the way, that the tip of this sealed phial being broken under water, sucked in a considerable quantity of it: whether, because of some little rarefaction of the air included in the sealing, or because of the infrigidation of that air by the snow, or for both these reasons, or any other, I shall not now dispute.

22. BUT other experiments to the same purpose we made, wherein the increase of weight was more considerable; and that the way, we used, may be the better understood, and the conclusion built upon it the more undiscussed, we will add a couple of trials, that we find among our notes concerning this matter.

[In a single phial we sealed up as much snow and salt, as afterwards, when melted, we found to weigh between five and six ounces; after a while, the salt beginning to melt the snow, the dew on the outside began to congeal, and being rubbed off, the hoar frost would quickly begin to come again. This phial for further trial being put into a pair of scales with a counterpoise, after a while, as the vapours, that wandered through the air in the warm room, happened to be detained more and more upon the outside of the glass, and to be there frozen, the scale, wherein the glass was, began to be deprest, and to shrink lower and lower; after which, by adding a little to the counterpoise, we reduced them again to an æquilibrium; and yet after a while, the scale, that held the phial, subsided again more and more, till the included snow

was melted: so that to reduce the scales to their first æquilibrium, we were fain to add in all to the counterpoise a weight, which we estimated to be about eight or ten grains, (for we had then no great weights by us.) The phial being taken out, there appeared near half a spoonful of liquor in the scale it stood in, which proceeded from the thaw of the ice, that was generated about it. But in that part of the scale, which was covered with the convex part of the bottom of the glass, there appeared no wet.

A LIKE or smaller quantity of snow and spirit of wine being sealed up in a single phial, the outside quickly appeared cased with ice as high as the mixture reached within, and this phial also being counterpoised in a pair of scales, did by degrees depress the scale, that held it, till it had sunk it very low, and about seven grains did but reduce the scales to an æquilibrium; but the scales being somewhat rusty, we could not make the trials with that exactness we desired.]

23. BUT at other times, when the experiment was more luckily, though not more carefully tried, with better scales, the increase of weight from the condensed vapours of the air was somewhat more considerable; for I find in a short note,

[THAT at one time a mixture of spirit of wine and snow, weighing three ounces and three quarters, afforded of condensed vapours about 18 grains.

AND at another time a mixture of snow and sal gemmæ, weighing three ounces and seventy grains, procured us an accession of water weighing about 20 grains.]

T I T L E II.

Experiments and observations touching bodies disposed to be frozen.

1. **I**T were almost endless to try particularly, which bodies are or are not capable of congelation, and the degree of cold would also in such experiments be (as near as men can) determined; because many bodies will freeze in one degree of cold, that will not in another: wherefore we are willing to leave these trials to those, that have more leisure and opportunity to prosecute them, and shall only set down some, and those somewhat various, that we may not leave this part of the History of Cold quite unfurnished. And we must mention the fewer, because, being in the country, we were not provided of divers of the bodies, which we should have exposed.

2. IN very cold snowy weather, we tried that (besides common water) urine, beer, ale, milk, vinegar, and French and Rhenish wine (though these two last but slowly) were turned into ice, either totally, or in part. But such instances will possibly be thought too obvious to be insisted on; therefore I shall add, that not only we froze a strong solution of gum arabick, and another of white sugar in common water, but that we took alum, vitriol, salt-petre, and sea-salt, and made of each of them in a single phial as strong a solution as we could; we also made a strong solution of verdgrease in fair water (which was thereby deeply coloured) all these we exposed to the cold air. The solution of alum, nitre and verdgrease froze without affording any notable phænomena, either in the figuration of the ice, or otherwise: of the solution of vitriol there remained, at the bottom of the glass, a pretty quantity unfrozen, and of a clear substance, whose colour was very high of the vitriol; whereas the upper part of the same solution differed very little in colour from common ice.

3. BUT because it seems not so strange, that these gross sorts of saline bodies should be turned into ice, we thought fit to try, whether or no also divers salts, freed from

from the grosser parts of their concretes by the fire, were not likewise capable of congelation. We exposed therefore spirit of vinegar in one small glass, and spirit of urine in another, to an intense cold, and found, that not only the former, but the latter also froze.

4. WE took likewise some of the fiery lixivate salt of pot-ashes, and a single phial, in which we put, to two ounces of water, a drachm of the alkali, and exposing it to a very sharp air, we did, when we came to see the success of the trial, find ice lying on the top in little sticks (something crossing one another) almost like the crystals of rock'd petre; and besides these, that lay levelled, there were others, that shot downwards in very great numbers.

5. WE also found, that oil of tartar per deliquium, or at least a strong solution of the fixt salt of tartar, though it seem'd much to resist the cold, yet it was once by snow and salt brought to congelation.

Appendix to the II^d. Title.

SINCE I wrote the present book concerning cold (expecting some of the appendices) having once had the opportunity of an hour's discourse with an ingenious man, that not only lived some years in *Muscovy*, but was, and is still physician to the great monarch of that empire; and having likewise at other times conversed with navigators, and some other credible persons, that had travelled either to *Greenland*, *Terra Nova*, or other gelid climates, I propos'd them divers questions; by their answers to which, I learned some particulars, which, together with others, that I have met with in voyages and other books, I think it not amiss to annex by way of appendices to the foregoing, and some of the following sections, or titles.

ABOUT the freezing of common express'd oils, I know not well what to determine; for that they may, by a very intense cold, be deprived of their fluidity, and be made capable of being cut into portions, that will retain the figure given them, my own trials invite me to believe: but whether such oils will be turned into true (by which I mean) hard and brittle ice, is a question scarce to be determined by any experiments we can make here in *England*, where we could not reduce oil-olive into ice. And for the relations of those, that have lived in colder countries, I find them to disagree: for when I asked the lately mentioned doctor the question, how far he had known oil congealed in *Muscovy*? he answered me, that it did there freeze much harder than in our climate, but would not, that he had observed, be turned into true and perfect ice. On the other hand, I find the testimony of that ingenious navigator captain *T. James*, who relating the effects of cold he met with in the island, where he and his men were forced to winter, does in one place reckon oil among the liquors, such as vinegar, and sack, that even in their house was firmly frozen, and more expressly elsewhere; "All our sack (says he) vinegar, oil and every thing else, that was liquid, was now frozen as hard as a piece of wood, and we must cut it with a hatchet." And *Olaus Magnus* speaking of the fights, wont to be made upon the ice in the northern regions, *Glacialis congressus* (says he) *fit in laneis calcibus, non pellibus, aut coriis unctis: vis enim frigoris, quodcumque sit unctuosum, convertit in lubricitatem glaciale*.

THERE being a great similitude in point of inflammability, and disposition to mix with many subtle oleous bodies, betwixt spirit of wine and oil, and as great an affinity in divers other regards, betwixt that spirit and both aqueous and saline liquors, with which it will readily mix; I had a great curiosity to know, what kind of change would be produced in vinous spirits, in case they were exposed to a cold great enough

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Olai Magni
Gent. Sept.
Hist. l. 11.
c. 24.

to work a visible change in their texture. I therefore solicitously inquired of the *Russian* emperor's lately mentioned physician, whether or no he had observed in *Muscovy* any manifest change produced by cold in hot waters, and spirit of wine? To which he returned me this answer; that common aniseed-water, and the like weak spirits, would be turned into an imperfect kind of ice; and that even the very strong spirits, though they would not be turned into ice, would be turned into a kind of substance like oil.

T I T L E III.

Experiments touching bodies indisposed to be frozen.

1. **W**E found many liquors, whose subtile parts being by distillation brought over, and united into very spirituous liquors, and so either totally, or in great measure freed from those phlegmatick or aqueous parts, that dispose bodies to congelation, could not be brought to freeze, either by the cold of the external air, to which in frosty nights we exposed them, or by such an application of snow and salt, as served to freeze other bodies.

2. Of this sort were, among acid menstrooms, aqua fortis, spirit of nitre, of salt; also oil of turpentine, and almost all, (I add the word almost, because the essential oil of aniseeds and the empyreumatical oil of common oil will lose their fluidity in a less degree of cold, than that of our mildest frosts) I say almost all the chymical oils we had by us, as likewise spirit of wine, and other strong spirits of fermented liquors, and even sack itself, if it were good, would very hardly be brought to afford us any ice at all: but among the many liquors, that would not freeze, there were a few, whose trials afforded us some circumstances not altogether unworthy their being mentioned.

As 1. I being desirous to satisfy some friends, that it was the brisk spirit of the grapes, whether resulting from, or extricated and exalted by fermentation, that kept (all) the rest of the sack from freezing; I took a parcel of that liquor, that would afford us no ice at all, and by the help of a lighted candle, or some other actually flaming body, kindled it; and letting the inflammable part burn away, the remaining part of the liquor (which was by vast odds the greatest part) was easily brought to freeze.

NEXT, when the formerly mentioned trial was made with water and pot-ashes, we likewise, in another glass, exposed a solution, wherein the proportion of salt of pot-ashes, in reference to the water, was four times greater; there being in this ziii. of the salt to 3j. only of water: and this solution, though the glass were covered with hoar frost and ice on the outside, froze not at all within. And likewise, when another time we made a very strong solution of salt of tartar, that was very pure and fiery, it did not freeze, though a considerably strong solution of salt of pot-ashes, that was exposed with it, did. So that these experiments about the glaciation of lixivate liquors must be repeated, to be reduced to a certainty.

3. THAT the common expressed oils of vegetables will, after their manner, freeze, that is, lose their fluidity, and become, as it were, curdled in very cold weather, is a matter of common observation; but I had a mind to try, whether or no train oil, that is made of the fat of animals, (commonly that of whales) though not by distillation, properly so called, yet by the help of fire, would not be more capable of resisting the violence of the cold; and accordingly I found, that train-oil, exposed to the air in a convenient phial, continued fluid, notwithstanding a more than ordinary sharpness of weather: and this I tried two or three several times, but at length one night

night proved so very cold, that the next morning I found the oil unfluid. Which differing events seem a little to countenance, but more to disfavour the report of *Olaus Magnus*, who writes, that whereas in northern regions it is usual for strong places to lose in winter the protection afforded them in summer, by their ditches, though never so wide and deep, because the frost makes them easily passable to the enemy; this inconveniency is wont to be prevented by pouring into the ditches, the ice, if there be need, being first broken, great store of this train oil, which swimming upon the surface of the water, and being incongealable by the cold, protects the subjacent water from the freezing violence of the cold, and keeps the moats unpassable. But because our author mentions this as a known and vulgar practice in those icy regions, it may perhaps deserve a little enquiry, whether the whale oil, used by the Swedes, Laplanders, Muscovites, and other inhabitants of those parts, be not differing, either as to the fishes it is made of, or as to the way of making it, or as to the way of keeping it, from such train oil as we employed; unless perhaps it do already appear by the relation of writers belonging to those countries, or of travellers, that have been in them, that *Olaus Magnus* has in that particular, as I fear he has in some others, misinformed his readers.

Olaus Magnus in *Historia Gentium Septentrionalium*, lib. II. cap. 20. & 21.

4. WE took notice, that a strong solution of common sugar was easily enough turned into ice; but on a strong solution of sugar of lead we could not with salt and snow work the like change, and this, though the trial were not negligently made: which I therefore think not unworthy to be mentioned, because that the two only ingredients of this sugar were lead, which is esteemed a very cold body, and spirit of vinegar, from which, as I noted above, we did, by the like degree of cold to that we here employed, obtain ice. And though in this metalline sugar, we may well suppose the saline parts of the spirit of vinegar to be much more concentrated or united, than they were in the spirit; yet the solution must abound with aqueous parts: and this sugar seeming but a kind of vitriol of lead, it is worth our notice, that its solution would not freeze, as well as that of common vitriol, though in this latter concrete, metal be corroded by a spirit, which, as far as can be judged, by the liquors afforded in distillation, is very much sharper and stronger than spirit of vinegar.

5. WE likewise tried to freeze quicksilver, and for that purpose provided a bubble, that being blown with a lamp, was but thin, and so flat, that the sides almost touched, and it held but a little mercury; and that by the figure of the glass, being reduced to a large surface, with but very little depth or thickness, it was far more exposed, than if it had been in an ordinary round bubble, to the action of the cold. But we could not at all freeze this extravagant liquor, though we tried it more than once, and though the last time we exposed it in the same vessel to the same degree of cold, wherewith we made one of the following experiments, that required a very intense degree of that quality. And in another thin glass-bubble we long exposed quicksilver to an extraordinary sharp air: but though the cold had some operation upon it, not here necessary to be mentioned, yet we could not find, that it did at all bring it to freeze. Wherefore I could wish that trial were made in *Muscovy*, *Greenland*, *Charles-Island*, or some other of the most icy regions, where the effects of cold (which are here upon quicksilver but languid) are the most considerable, and sometimes stupendous.

6. IT is very remarkable, that though not only the solutions of other gross salt, but, as we have seen, divers more saline and spirituous liquors, were brought by snow and salt to congelation; yet a brine made very strong of common salt, could not be brought to freeze at all, though we kept it exposed with the other saline solutions,

that

that did freeze, during a whole night, that was exceeding sharp. Which experiment I also tried many years since, to draw thence an argument in favour of the Cartesian hypothesis about cold, which I shall not now consider; but rather add, that being desirous to try, with what proportions of sea-salt and water the congelation of them might be effected, I found, I could freeze some sea-water, that had been brought up in a barrel to that monarch of the virtuosi, the King, for the making of trials with it; and that having in a single phial exposed to the air, in a very bitter night, a solution consisting of twenty parts of water, and one of salt, which is double the proportion of salt to be commonly found in our sea-water, the next day we found a good part of the liquor frozen, the ice swimming at the top in figures almost like broom, spreading from the surface of the water downwards. And to add that upon the by, we suffered the ice of salt water to thaw, to try, whether it would yield fresh water, but it seemed not devoid of some brackishness, which, whether or no it proceeded from some parts of the contiguous brine, that adhered to the ice, I leave to further and exacter observations, since I am credibly informed, that in *Amsterdam* there are divers, that use the thawed ice of the sea-water to brew their beer with, instead of common fresh water.

Cap. vi.
page 42.

3. AND since I made that experiment, I find in the industrious *Bartholinus's* newly published book, *De Nivis Usu*, a confirmation of the probability of the report I just now mentioned, his words being these; *De glacie ex marinâ aquâ certum est, si resolvatur, falsum saporem deposuisse; quod etiam non ita pridem expertus est Cl. Jacobus Finckius Academiæ nostræ senior, & physices professor, bene meritus, in glaciei frustis è portu nostro allatis.*

TITLE IV.

Experiments and observations touching the degrees of cold in several bodies.

1. **A**FTER having treated of the bodies, that are the most capable of producing cold, and of those, that are most disposed or indisposed to receive it, it would be methodical to take notice of the *Degrees of Cold*, to be met with in differing bodies. But though a work of this nature might somewhat conduce to the discovery of cold in general, yet it is so laborious a task; and, to be well performed, requires so much more of leisure, and conveniency, than I am master of, that I must resign it to those, that are better furnished with them. Which I the freelier do, because the experiments, which at this time make the principal part of our history, being chiefly of the highest *Degrees of Cold*, we may seem to have done something of what more properly concerns our present design, by having made the experiments, anon to be subjoined within this present section or title. And yet thus much we elsewhere do toward the framing of a table of the *Degrees of Cold*, that we do on other occasions set down those hitherto unpractised ways, that we have employed, to estimate the greater or lesser coldness of bodies, by several kinds of weather-glasses, differing from the common ones, and far more fit than they, for such a purpose. For by hermetically sealed thermoscopes furnished with high rectified spirit of wine, we can estimate the differing degrees of coldness in liquors, of which we shall presently mention an example. And by using such weather-glasses, as have their air included not at the top, but at the bottom of the instrument, we can, within some reasonable latitude, measure the coldness both of intire solid bodies, or minuter bodies, as salts, &c. by heating them alike, and very small, and placing the instruments at equal depths in the powder of each of them: and besides, that the shape of these thermoscopes does, as we have elsewhere shewn, make them proper for these uses, for which the vulgar ones,

ones, where the included air is at the top of the instrument, are not fit; besides this, I say, it is easy in these we make use of, to make the pipe so slender in proportion to the cavity of the phial, whercinto it is inserted, that very much minuter differences of cold will be manifest in these, than are wont to be sensible in common weather-glasses. And besides these two sorts, we have elsewhere proposed, and described a third and new kind of thermometer, wherein a drop of liquor being suspended in a very slender pipe of glass, betwixt the outward and the inward air, makes it far more fit for those experiments, wherein we either despair, or care not to measure the difference of cold betwixt two bodies, but are only desirous to try, whether or no they differ in coldness; and in case they do, which of them has most: for these weather-glasses are so exceeding sensible even of the minute difference of heat and cold, as manifestly to discover disparities, which other thermoscopes are not nice enough to give us any notice of. Only this advertisement we must add about them, that when we use them to examine the coldness, not of liquid, but of consistent bodies, we alter a little the figure of the wide end of the glass; and instead of making it a round bubble, as we have elsewhere described, we make it with a flat or flattish bottom, that the whole instrument might thereon, as on a basis, stand of itself upright, and so, being still taken up by the open and slender end, for fear of rarifying the included air, (which caution is here given once for all) may be transferred with a pendulous drop in the pipe, and placed sometimes on one, and sometimes on another of the solid bodies to be examined by it. For if the body, it is moved to, be more or less cold than that it rested on before, that coldness communicated through the glass to the air, by which the pendulous drop is supported, that air's expansion or contraction will manifestly appear by the rising or the falling of the drop. And thus we have taken pleasure to remove it from one kind of wood to another, from woods to metals, and from metals to stones, &c. But the expedients, that may be proposed to improve these little instruments to the purposes we have been treating of, and the cautions, that may be added to prevent men's drawing mistaken inferences from the informations they seem to give them, will take up more time, than we are willing to spend upon an occasion, that will not perhaps be thought to deserve it, nor much to require any others, than those we shall by and by subjoin. And therefore I shall proceed to the experiment promised at the beginning of this title or section.

2. To make so much as a tolerable estimate of the difference betwixt such great degrees, as are not any of them too weak to congeal water, is a thing, which as we have not yet known to be attempted, so it seemed not easy to be performed. For freezing having been commonly reputed the ultimate effect or production of cold, men have not been solicitous to look beyond it. And though the disparity we find betwixt several fits of weather, all of them frosty, seem to be too manifest and frequent to be probably ascribed to nothing, but the differing dispositions of our bodies; yet how to estimate that difference, it is not so obvious. For though we should have recourse to common weather-glasses, yet they might easily deceive us, since not only by estimating by them, the coldest day of one winter with the coldest day of another, but in judging of the coldness of any two days in the same fit of frosty weather, there intervenes time enough to make it doubtful, whether the varied gravitation of the atmosphere produce not the change observed in the weather-glass. Besides that, admitting vulgar thermometers could not, as they easily may, mis-inform us, they are employed only to give us an account of those degrees of cold, which nature, of her own accord, produces in the air; but not to discover, whether or no nature, assisted by art, may not produce greater: and, it will easily be granted, that they are yet less made use of to help us to an estimate of this disparity. And though some guess may

See preliminary discourses.

be made by the operations of cold upon liquors exposed to it, yet some, as water, and very aqueous liquors, will freeze too soon, and others, as vinous spirits, will not at all, (that we have found) here in *England*. And though French wine will sometimes be brought to begin to freeze, yet that happens but very seldom, and in many winters not at all, and leaves too great an interval betwixt the degrees necessary to congeal wine, and sufficient to congeal water; not to mention the uncertainty proceeding from the differing strengths of the wines.

3. UPON these and other considerations, we thought it requisite to make use of an expedient, whose nature and use will be easily gathered out of the following experiments: and though by a mischance, that broke my weather-glass, I have been hindered from measuring exactly in what proportion to the whole bulk the spirit of wine was contracted, by the surplussage of cold, that was more than necessary to make water freeze, yet I doubt not but something of use to our present theme, may be thence collected, and especially the main thing designed will manifestly appear, which is the intensity of cold produced by art, beyond that, which nature needs to employ upon the glaciating of water.

[4. A SMALL sealed weather-glass furnished with spirit of wine, the ball being about the bigness of a small nutmeg, and the cylindrical stem being very slender, and about ten inches long, the ball and part of the stem being immersed in a vessel of water, half buried in snow and salt, when the water began to freeze at top, the bottom and the sides, (but before the ice had reached the ball, for fear it should break it) the tinted liquor was found subsided to $5\frac{1}{2}$ divisions, being half inches; and being taken out thence, and ice and salt being immediately applied to the ball, the liquor fell lower to about $1\frac{1}{2}$ division.]

AND that it may not be doubted, but that the water, though in part congealed, remained warm in comparison of the spirit of wine, though uncongealed, that had been refrigerated by the snow and salt, we will add this other experiment, which we find in another of our notes thus set down.

4 Jan. 25.

[5. THE sealed weather-glass being kept in the water till it began to freeze, descended to 5': being immediately removed into the same snow and salt, that made the water begin to freeze, it descended at the beginning very fast, and afterwards more slowly, till it came to the very bottom of the stem, where it expands it self into the ball; then being removed into the same glass of water, whence it was taken, and which was well stored with loose pieces of ice, it did nevertheless hastily ascend at the beginning, and was soon after impelled to the former height of five divisions and an half, or thereabouts.]

6. BUT perhaps some amends may be made for the disaster of the weather-glass, by adding, that I found by another trial, that the condensation of liquors by such colds, as we are wont to have, or can easily produce here, is nothing near so great as one would imagine. And though for want of a glass-ball, furnished with a neck slender enough, I could not make the experiment so much to my satisfaction, as perhaps else I might have done; yet the goodness of the scales I have made use of, and some greater care, than possibly every experimenter would have employed, may make the following observation luciferous.

7. WE took then (on a cold, but not frosty day) oil of turpentine, as a liquor, whose being free from phlegm or water we could easily be more certain of, than if we had employed spirit of wine; and this oil itself we rectified in a gentle heat, to make it the more pure and subtile. Then we took a small round vessel of clear glass furnished with a conveniently long stem or pipe, and having first weighed the glass alone in a pair of very good scales, we found it to weigh 3i. 5i. 56' gr. Then putting
in

in oil of turpentine, till it filled the round part of the glass, and ascended a little way into the stem, we carefully marked with a diamond on the outside of the glass, how high it reached, and then weighed the glass and the oil together, which weighed 3ij. 3vij. and 34¹ gr. Then we put in, by degrees, a quarter of a drachm, and with a diamond carefully marked how high it reached in the pipe, and so we continued putting in several quantities of oil, still carefully weighing each parcel in the scale, and marking its height on the outside of the glass (which we did in order to a certain design, and found it a work tedious and troublesome enough) till the liquor and the glass together weighed 3ij. 5i. 4¹ grains. Then we put fair water into an open-mouthed glass, in which we also placed the little bolt-head with oil of turpentine, and by such a circumposition of salt and snow, as is * hereafter to be often mentioned, we made the water, which was contained in the wide-mouthed glasses, and by which the spherical part of the bolt-head, containing the oil, was surrounded, we made this water, I say, begin to freeze; and when we perceived a little ice to be produced in it, we carefully marked with a diamond, to what part of the stem the oil of turpentine was subsided, and then transferring the bolt-head into a mixture of snow and salt, where we kept it for an hour or two, till we could perceive it to fall no lower, and marking with a diamond, this station also of the liquor, we afterwards removed the glass into a warmer air, till the oil, by expanding it self, had regained the highest mark, whence it had begun to sink. Then into a very little glass, carefully counterpoised in a pair of exacter scales than the former, we gently poured out of the oil, till what remained rested against that mark on the outside of the stem, to which it fell, when the water began to freeze: and this we found to amount to somewhat above 9¹ grains; so that, for conveniency of reckoning, we may safely enough take the intire number of 10 grains. After this, we poured out of the remaining oil into the same little glass, till what rested in the pipe was even with that mark, to which the snow and salt had made it fall; and this parcel of oil happened to be almost precisely of the same weight with the other: so that in this trial (for perhaps in others, which it were therefore worth while to make, the degree of cold may much vary the events) the artificial way of freezing we employed, made the oil subside as much after it had been refrigerated and condensed by a cold capable of freezing water, as that degree of cold had been able to condense it at first. And lastly, having deducted the weight of the glass from the weight of the whole oil and glass, to obtain the weight of the oil alone; and having divided the weight of the whole oil, first, by that of the former parcel, we have mentioned to be ten grains, and then by the superadded weight of the second parcel, we took out, (both which parcels together we estimated at twenty grains) we found that rectified oil of turpentine of a moderate temper, being exposed to such a degree of cold, as would freeze common water, did, by shrinking, lose but about a ninety-fourth part of its bulk; and being reduced to as great a degree of cold as we could bring it to by snow and salt, even then it lost but about a forty-seventh part of its bulk: I say about, because I thought it needless, as well as tedious, to mind fractions and little odd numbers; especially since, as we formerly intimated, it was scarce possible to arrive at a great exactness in such a neck as that of our bolt-head, though it were proportionable enough to the ball, and chosen among several, that were purposely procured for the trying of experiments.

8. THERE are some other trials about the degrees of cold, which for want of ice and other accommodations we could not make, as we would have done often; nor shall scarce be able to do it, till more friendly circumstances afford us an opportunity: and yet because our trials, though not prosecuted as far as we thought,

* See the latter part of the next title.

may possibly prove not unwelcome, we will subjoin something about two of the chiefest of them.

9. THE one was designed to measure in what proportion, water of a moderate degree of coldness, would be made to shrink by the circumposition of snow and salt, before it begin by congelation to expand itself: of this, what we shall here take notice, is only, that by a trial purposely made with common water, in a round glass furnished with a long stem, we found the water in that stem to subside so very little, that, whether or no it were insensible, it was inconsiderable. But probably a greater quantity of water, and a slenderer stem, would have made the shrinking of the liquor more notable, and upon that account it is, that I here mention it.

10. THE other thing was, to measure by the differing weight and density of the same portion of water, what change was produced in it, betwixt the hottest time of summer, and first a glaciating degree of cold, and then the highest we could produce by art. And in order to this, we weighed with a pair of exact scales, a glass bubble heavier than water, in that liquor when it seemed to be at a moderate temper, as to coldness, and by the diminution, which we found of the glass's weight in the water, we easily collected, according to the rules of the hydrostaticks, the weight of as much water, as is equal in bulk to the glass bubble, and thereby the proportion betwixt the glass and an equal bulk of such water, as we first weighed it in: then by the application of snow and salt, we made that water begin to freeze, and weighing in it again the same bubble, it was easy to collect, by the decrement of its weight in this refrigerated water, what proportion an equal bulk of the liquor did then bear to the glass: and by comparing these two differing proportions together, we were assisted to make an estimate, how much the water was made more heavy and dense by the action of a freezing degree of cold. Afterwards taking our time in summer, we thought fit in the same parcel of water (that had been purposely reserved in a glass) to weigh the same bubble, that by the difference of its weight in the water, when made much lighter by the heat of the ambient air, we might obtain the information we desired. To which we shall add, that we also recommended to some Virtuosi, that were likely to have the opportunity of gratifying us, that such an experiment might be procured to be made in the midst of summer in some part of *Italy*, by the help of the there not unfrequent-conveniency of a conservatory of snow, wherein the water might be reduced to freeze before the end of the same hour, at whose beginning the there warmer air had given it its greatest expansion, and so the difference betwixt the density of the same parcel of water might be the more conspicuous. But as I have not received any account of my desires from abroad, so coming now at home to review the memorial, I caused to be written of the newly mentioned observation, I find, that through the negligence or mistake of an *Amanuensis*, there must needs be a manifest oversight committed in the setting down the numbers which my memory does not now enable me to repair. And the season being now improper to repeat the experiment, as well as the numerical parcel of water I had kept, and I employed both times, being thrown away, I think it may be sufficient, if not too much, to have thus particularly intimated the way we took, without adding the cautions, wherewith we proceeded, nor what trials we made to the same purpose with high rectified spirit of wine, since unlucky accidents frustrated our attempts.

11. WHETHER the making of these kind of trials, with the waters of the particular rivers or seas, men are to sail on, may afford any useful estimate, if, and how much, ships and other vessels, may on those waters be safely loaden more in winter than in summer, may be an inquiry, of which I shall not in this place take any further notice, than to intimate thus much, that the difference betwixt water highly refrigerated, and
that,

that which is but of an usual degree of coldness, is not so great, as some learned moderns seem to have thought. For on a day, which (though made cold by snow intermingled with the rain that then fell) was not a frost, we took common water, and weighed in it a glass bubble, whose weight in the air was 150 grains, and this bubble, weighed in that water, lost so much of its former weight, as to weigh about $28\frac{1}{2}$ grains: and then by snow and salt, reducing that water to such a degree of coldness, that it began to be turned into ice about the inside of a small open glass that contained it, we found the same bubble not to weigh at all above one eighth part of a grain less than it did before. So that if we may judge of the shrinking and condensation of the water by the increment of weight, it shrunk but about a 230th part of its former bulk, and this according to a pair of scales, that would turn with about the 32d part of a grain: which may keep us from wondering at what we lately delivered concerning the very inconsiderable subsidence of the water, we exposed to snow and salt in a small bolt-head. And it may also make that the more probable, which we not long since related about the oil of turpentine's not losing much above a 1000th part of its bulk, by being exposed to such a degree of cold, as made water begin to freeze. Whether we may from this, and from the formerly recited experiment, of the great subsidence of spirit of wine in a sealed weather-glass, safely conclude, these subtiler distilled liquors to be much more sensible than waters of cold, as well as of heat, further trials will best resolve: and these I have not now so much opportunity, as I could wish, to pursue.

12. But they that have a mind to prosecute experiments of this kind, and others, that relate to the degrees of cold, may perchance be somewhat assisted even by these relations, and especially by those passages, that mention the use of the sealed weather-glass, furnished with spirit of wine, and of those wherein a drop of liquor is kept pendulous. For the former of these being not subject to the alterations of the atmosphere's gravitation, (nor, as may be probably supposed, by reason of the strength of the high rectified spirit of wine) to be frozen, by sending the same weather-glass (which may be portable enough, as I have tried by transporting one of them in a case, that might be easily carried even in a pocket) from one country to another, one may make far better discoveries of the differing degrees of coldness in differing regions, and know (somewhat near) how much the air even of *Muscovy*, or *Norway*, or *Greenland* itself, is colder than that of *England*, or any other country, whence the weather-glass shall be sent: the instrument being accompanied with a memorial of the degree, it stood at, when exposed to such a cold, as made water begin to freeze.

13. THE other thermometer, where a drop of liquor is kept pendulous, may not only be employed in such cases, where the pipe and bubble can be erected upon the horizon, but by reason, that the outward air will indifferently impel the bubble laterally or upwards, upon the refrigeration of the inward, and that the bubble will not barely by its weight drop out of the inverted instrument, because of the resistance of the subjacent outward air; for these causes, I say, such a thermoscope may, as we have tried, be also used, where the pipe shall be held horizontal, or inclined, or even perpendicularly downwards, so that the flat part of the bubble may be applied to discover the coldness either of the wall, or of the ceiling of a room, or other bodies however situated. And if the pipe be made long and even, (as sometimes we employ one above a foot long) not only sensible, but great effects of very little disparities in the coldness of bodies, to which the instrument is applied, may with pleasure be observed. And the same drop of liquor may be long enough preserved useful in the pipe. But this advertisement I shall give, that as sensible as this instrument appears

to be of the nicer differences of coldness, as of heat, yet they, that shall have the curiosity to examine with it, as I have done, the temperature, I say not, of more resembling bodies, but of liquors, that may be thought to have their parts so differently agitated, as common water, high rectified spirit of wine, and even rectified oil of turpentine, (I add not dephlegmed oil of vitriol, because of some odd phenomena not here to be insisted on) will perhaps find the event so little, in many cases, answer the expectation he would have had of uniformly finding great disparities in their actual coldness, if he had not met with this advertisement, that he will not much wonder, that a person, who wants not other employments for his time, was willing to decline so tedious and nice a task.

T I T L E V.

Experiments touching the tendency of cold upwards or downwards.

1. **T**HOUGH, after the consideration of the sphere of activity of cold, it would be the most proper place to take some notice of the direction of its activity, yet, because one of the experiments, that belong to this head, is of great use to facilitate the trial of many of those, that follow, throughout this whole collection; we will no longer delay to say something of this matter, namely, in what line, or, if you please, towards what part the frigefactive virtue of cold bodies does operate the furthest and the most strongly.

2. IT is a known doctrine among philosophers, that the diffusion of heat tends chiefly upwards, as the flame of a candle will burn many things held over it at a greater distance, than it would considerably warm them at, in case they were held beneath its level, or even by its sides: and it is true, that in all cases vulgarly taken notice of, the observation, for reasons elsewhere discoursed of, holds well enough; and therefore it may be worth enquiry, whether in cold, which is generally looked upon as the contrary quality to heat, the diffusion (from cold bodies) be made more strongly downwards, than either upwards or towards the sides.

ABOUT this matter, I can as yet find among my notes but the two following experiments, and those not both together.

[A VERY thin bubble was blown at a lamp, and purposely made flat at the bottom, that it might be the more exposed to the cold, and it was suspended by a string within a pretty deal less than an inch of a mixture of beaten ice and salt, wherewith we had half filled a conveniently large wide-mouthed glass; but we could not find, that a cold, capable of freezing, did strike so high upwards, for the water in the bubble remained altogether unfrozen; which agrees very well with what we have observed, that a mixture of ice and salt did not congeal the vapours, that wandered through the air, above half a barley-corn's breadth higher, than the mixture in the glass reached.]

3. [A MIXTURE of snow and salt being put into a phial with a long neck, the round part of it was by a weight kept under water, out of which being taken after a while, the outside of the glass beneath the surface of the water was cased with solid ice, N. B. especially about the bottom of the phial, of greater hardness and thickness than any one could easily imagine.]

4. THUS far the notes, from which nevertheless I will not positively conclude, though they seem to persuade it, that the tendency of the cold produced by bodies qualified to freeze others is greater downwards than upwards: for the satisfactory determination of that matter may, for aught I know, require trials more artificial and

nicer,

nice, than those we have been reciting. And I could wish, that I could find the last of them to have been carefully repeated and registered, because it seems somewhat strange, that the ice should be much thicker at the bottom of the phial, than elsewhere; in regard that when we have, as we very frequently have, put mixtures of snow and salt into phials, and left them in the open air, we generally observed, that the outside of the glass was cased with ice, or covered with hoar frost, directly over against that part of the inside of the glass, wherein the frigorifick mixture was. So that part of the snow and salt resolving one another, and falling down in the form of a liquor to the bottom, the unmelted part of the mixture would float upon this liquor, and the external ice would appear over-against the floating mixture, by which it was generated: so that as the mixture grew thinner and thinner, so would the zone or girdle, if I may so call it, of external ice, grow narrower and narrower, till at length, when the snow was quite melted away, the external ice would quickly also vanish. But from this observation (which we frequently made) that as in such phials the ice did not appear (as I just now related) above half a corn's breadth higher than the mixture, in the glass; so I remember not to have observed it much lower beneath the mixture: from those things, I say, it may be probably conjectured, that even the coldest bodies (at least unless their bulk alter the case) do not diffuse their freezing virtue, either upwards or downwards to any considerable distance.

5. THESE trials, as I was intimating, may suggest some difficulties about the last of the two experiments, transcribed out of my notes. But as it is evident these observations were made in the open air, by the freezing of its roving vapours, and the mentioned experiment was made under water; so how much this difference of mediums may alter the case, as to the way of the diffusion of cold, I dare not, till further trial, boldly determine: especially since one circumstance, to be under the next title mentioned, about the freezing of eggs, may pass for an additional experiment as to our present inquiry. For the cases obtained by frozen eggs suspended under water seem to argue, that the diffusion of their cold was made every way, since they were quite inclosed in the ice, they had produced.

6. THOUGH the experiment of freezing water, by the intervention of salt and snow, be not a new one for substance, yet I hold it not amiss, to make a further mention of it on this occasion. Because that what I am to deliver about it, is a particular not taken notice of (that I know of) by others: the premising of which will, according to what we lately intimated, much facilitate the trial of many of the experiments to be set down in the following part of these papers, and will indeed appear to be of no small moment in our whole attempt of framing an *History of Cold*. For it has long seemed to me one of the chief things, that has hindered men from making any considerable progress in this matter, that whereas glass-vessels are generally much the most proper to freeze liquors in, because their transparency allows us to see, what changes the cold makes in the liquors exposed to it; the way of freezing with salt and snow, as it has been hitherto used, does almost as little, as the common way of barely exposing vessels to the cold air in frosty weather, prevent the unseasonable breaking of the glasses. For in both these ways, the water or other liquor usually beginning to freeze at the top, and it being the nature of glaciation, as we shall see anon, to distend the water and aqueous liquors it hardens, it is usually and naturally consequent, that when the upper-crust of ice is grown thick, and by reason of the expansion of the frozen liquor bears hard with its edges against the sides of the glass contiguous to it, the included liquor, (that is by degrees successively turned into ice) requiring more room than before, and forcibly endeavouring to expand it self every way,

way, find it less difficult to burst the glass, than lift up the ice; and consequently does the former, and thereby spoils the experiment, before it be come to perfection, or have let us see what nature would have done, if she had not been thus hindered in her work.

7. THE consideration of this invited me to alter the common way of freezing, and order the matter so, that whensoever I pleased, the exposed liquor should not begin to freeze at the top or sides, but at the bottom; which I concluded it very easy to do, by mingling the salt with that part only of the snow, which was to lie beneath and about the bottom of the glass I placed in it. For by this means the snow, that was contiguous to the sides, was able but to cool the water, and dispose it to glaciation; whereas the mingled snow and salt, on which the bottom of the glass rested, did actually turn the neighbouring liquor into ice, and lift up the incumbent liquor towards the higher and empty parts of the glass. And this liquor also I could afterwards freeze at pleasure, without danger of breaking the vessel, only by so applying salt and snow to the sides of the glass, that they never reached, except perhaps at the very conclusion of the experiment, so high by a reasonable distance, as the upper surface of the liquor in the glass; so that the superiour parts of that liquor were always kept fluid, and capable of being easily impelled higher and higher, by the expansion of the freezing parts of the subjacent liquor.

In the
discourse
touching
the primum
frigidum.

8. THE speculative inference, that may be drawn from this experiment, of making water begin to freeze at the bottom, not the top, will be more properly taken notice of in another place: in the mean time, I shall only intimate by the way, that there is no great necessity of any nice proportion of salt to snow, nor of any exquisite mixture of them: a third or fourth part, or thereabouts, of sea-salt, in reference to the snow, will not do amiss; nor do I usually put salt to all the snow at once, unless in some case, wherein I have a mind to freeze a liquor quickly, and make a speedy resolution of the snow and salt in order thereunto. To which I shall only add, that by the way abovementioned, I do upon particular occasions make the exposed liquor freeze, not at the bottom or the top, but next to what side of the glass I please, according to the exigency of the experiment. But though it may suffice to have hinted the speculative inference, that may be drawn from this way of freezing liquors, it will be expedient to give explicitly this practical advertisement concerning it; that whereas it seems to have been taken for granted, that snow is necessary in this artifice, and we our selves were for some time led away with the rest by that supposition: yet that is but a presumption, and ought to be removed, as one very prejudicial to those, that with us design the prosecuting experiments, in order to the *History of Cold*. For snow is but seldom to be found on the ground in comparison of ice, and being but a congeries of many small icicles, with much air intercepted among them, it is not (*ceteris paribus*) near so durable, as the more intire body of solid ice. And yet we have found by frequent experience, that ice, well beaten in a mortar, will serve our turn for artificial glaciations, as well (if not in some respects better) as snow; and therefore in this *History of Cold* we indifferently prescribe snow and salt, or salt and ice, as the ingredients of our glaciating mixtures.

TITLE VI.

Experiments and observations touching the preservation and destruction of (eggs, apples, and other) bodies by cold.

1. **I**T is a tradition common enough, (though not here in *England*, yet among those, that have given us accounts of very cold countries) that if eggs or apples, being frozen,

frozen, be thawed near the fire, they will be thereby spoiled; but if they be immersed in cold water, the internal cold will be drawn out, as they suppose, by the external, and the frozen bodies will be harmlessly, though not so quickly thawed. This tradition I thought fit to examine, not only because it may be doubted, whether it will succeed in our more temperate climate, and because I love not to rely upon traditions, when I have the opportunity to examine them (especially if no one credible author affirms them upon his particular knowledge) but also because I thought the experiment, if true, might be so varied and made use of, as to become luciferous enough, and afford us divers phenomena of cold, not so easy to be produced by the more known ways of experimenting. And accordingly having exposed some of these bodies to a cold, that was judged sharp enough, we afterwards put them in water, but found not the event answer our expectations, no ice appearing to be generated: nevertheless we were not hereby so discouraged, as not to repeat the experiment (which we judged to be not unlikely) with more sollicitousness and advantage than before; and having thereby brought it to succeed, we afterwards made several trials of it with several distinct aims, but cannot now find any entry of divers of them. But those I have hitherto met with among my notes, I shall subjoin, as having in them some particulars, that may afford useful hints to an inquirer into the history and nature of cold. And I shall set down together, and that in this place (though it would not otherwise be the most proper) those I have met with, because some circumstances of one or other of them may be of use to us on several occasions in the present treatise.

2. [AN egg weighing twelve drachms and one grain wrapt in a waxed paper (to keep it from the liquor of the thawing snow) and frozen with snow and salt, wanted four grains of that weight: put into a dish of fair water, there crufted as much ice about the outside, as made the egg and ice fifteen drachms and nine grains. The ice being taken off from the shell, and the shell very well dried, the egg was found to weigh twelve drachms and twelve grains; the egg being broken, was found almost quite thawed; the egg frozen swam in water; being thawed, it sunk.]

3. [WE took two eggs strongly frozen, and in a room, where there was a good fire, we put one of them into a deep wooden dish full of very cold water, and set the other by it, upon a table about two yards from the fire, that they might be in air, of the same temper as to heat and cold; then perceiving the egg, that lay under water, to have obtained a thick cruft of ice, we took it out; and having first freed it from the ice, broke it, and found, that some part of the white was not yet freed from a pretty store of little parcels of ice, but the rest of the white (which was much the greater part) and the yolk seemed to be much-what of the same consistence, as if the egg had not formerly been frozen; whereas the other egg, that lay by upon the dry table, had not only its whole white frozen into a consistent body, but the yolk it self, though we saw no distinct particles of ice in it, was grown so hard, that it cut just like the yolk of an egg over-boiled; and being cut quite through, shewed us certain concentric circles of somewhat differing colours, with a speck much whiter than any of them in the middle of the yolk; which last circumstances, whether they were accidental or no, further observation must determine.]

NOTE, that though we have not found above once, that frozen eggs would swim, yet when we had broken such eggs, the frozen white would swim, but not the yolk.

4. WE afterwards repeated the experiment of laying two frozen eggs near together: in the place above mentioned, the one under water, and the other out of it, till that put in water had got a thick icy cruft, and by breaking of them both, presently after
one

one another, were confirmed in the persuasion, that frozen eggs will thaw by great odds (*ceteris paribus*) faster when immersed in water, than when surrounded only with air.

5. [We likewise took a frozen egg, and from a fixed place suspended it so by a slender packthread, that it hung quite under water, without yet touching the vessel, that the water was in. This we did partly upon another design, and partly to observe, whether or no the ice would in this case be considerably thicker or thinner against the lower parts of the egg, as we formerly mentioned ourselves to have observed it to be very manifestly at the lower parts of a glass, which having ice and salt in it, was immersed under water; but when we took out the egg, after we saw, that its icy case had covered the packthread it was hung by, we found the case, upon breaking it, of a thickness uniform enough to keep us from concluding any thing from this trial; since, though there were a pretty deal of ice generated at so small a distance from the case of the egg, that it seemed to owe its production to the same cause, yet, which was somewhat odd, we did not find, that this ice stuck to that, which did immediately imbrace the egg, though we had some faint suspicion, that the rudiments of it might have been very early parted from the egg, by some little shaking of the table, occasioned by people's passing to and fro in the room.]

6. [We took some pippins, and exposing them to freeze all night, and putting them the next morning into a basin of very cold water, (though in a warm room) they were not long there without being inclosed with cases of ice of a considerable thickness. Where note, 1. That that part of a floating apple, that was immersed under water, had a very much thicker coat than the other part, which remained above it. 2. That the extant part seemed likewise to be harder than the immersed. 3. That one of these pippins being purposely left out of the basin, but laid by it, seemed, upon cutting, to be harder and more frozen than those apples, which had been put into the water; which scarce seemed to be at all harder than ordinary pippins, that had never been set to freeze, at least as to those parts of the apples, that were near the rind, and consequently near the ice. 4. That neither frozen pippins nor frozen eggs, notwithstanding their great power of turning part of the contiguous water into ice, did appear to us to detain or congeal any of the roving vapours of the air, as ice or snow included with salt in glasses is (as we have formerly observed) accustomed very remarkably to do.]

7. [We took eggs, and froze them with ice and salt, till the shells of them were made to crack: then we took them out, and put one of them in milk, two of them in a wide drinking-glass full of beer, and two more in a large glass, wherein we covered them with sack, that was poured in till it reached much higher in the glass than the eggs. But none of these trials produced, as we could perceive, one grain of ice.] And being desirous to see, whether the acid salt of vinegar, or the cold in a well-frozen egg, would have the chief operation, if those two bodies were put together; I found upon trial, that the saline parts of the vinegar began to dissolve the egg-shell, as appeared by the much altered colour of it, but the cold of the ice in the eggs was not able to freeze any part of the water or phlegm of the vinegar.

8. We had also thoughts of trying, whether or no pieces of iron of several shapes and bignesses, being for divers days and nights exposed to the freezing air, and afterwards immersed in water, would produce any ice, as frozen eggs and apples do. For the brittleness of the laths of stone-bows in sharp frosts, together with other observations elsewhere mentioned, seem to argue, that (to use a popular phrase) the frost does

does also get into these bodies. And I have been assured by one, whom the trials I had made with eggs and apples, invited me to consult, that a great cheese he immersed in water in a cold country, was presently covered over with ice. But though, as I said, I had thoughts of making the above-mentioned trials, yet for want of a frost sufficiently durable, I was not able to effect what I designed. But thus much I tried, that though I kept good lumps of iron, and, as I remember, of other metals, besides pieces of glass, and a stone or two of a convenient size, in snow or salt, I know not how much longer, than would have sufficed to make eggs or apples, or such kind of things, fit to produce store of ice in water, upon their being thawed therein; yet we could not find, that upon the immersing the several newly named mineral bodies, there was the least ice produced in the cold water, where we kept them covered. I must not, nevertheless, omit to make some mention of that, which lately seemed to happen at the door of our own laboratory, (respecting the north east) where some glasses, newly brought from the shop, and not employed, lying in a basket, as they poured water into one of them to rinse it, part of it was presently turned into ice, whilst one of my domesticks held it in his hand; who coming presently to shew it me, I suspected the ice might have come from, or rather with the water, that was poured into the glass, but upon inquiring was assured of the contrary.

9. But here I must not omit another trial relating to the former experiments, which may seem somewhat odd, if its event prove constantly the same, as when we tried it. For after these and divers other experiments made with frozen eggs and apples, we thought it might be worth the examining, whether or no ice and the liquors of these concretes would produce the like effects, as frozen eggs and apples. And because it is usually an easier way than that, which is more common, of bringing bodies, whose degree of cold is more languid, to freeze water, to include them with ice or snow in a single phial, and so put them upon acting only upon the minute, and easily congealable vapours, that wander in the air; we took that course in the trials we are mentioning: whose success is thus briefly set down in one of our notes.

[10. Ice and juice of pippins, well shaken together in a single phial, produced abundance of dew; but we could not satisfy ourselves, that it produced any ice.]

[11. Also ice and the white of an egg, moderately beaten into a liquor, were tried, with just the like success; but these trials having scarce been made above once, and at most but twice, are to be repeated.]

12. As for what is said, that eggs and apples thawed in the water are better preserved than thawed by the fire's side; we tried it in pippins, (for in eggs the experiment is not so easily and quickly made) and, as far as we could discern, found it true, and somewhat wondered to see, how soon, and how much putrefaction was induced into those loosely contexted bodies by an overhasty thawing.

13. If we may believe the relations of navigators, and others of good credit, (of one or two of whom I had the opportunity to make inquiry) there may be good use made of what happens in the different ways of thawing eggs and apples, by applying the observation to other bodies, and even to men, that happen to be dangerously nipped by excessive cold. For it is a known observation among those, that have inhabited or visited the northern climates, that if those, whose hands or feet, or faces happen to be frozen, approach them too near or hastily to the fire, they are in danger of losing, or at least much prejudicing the over-hastily thawed parts. 'Upon divers of us,' (says Captain *James*, speaking of his companions) 'had the cold raised blisters as big as walnuts. This we imagined to come, by reason that they came too hastily to the fire.' And therefore they, that are more careful to be safely than

quickly delivered from the painful cold, are wont, before they come near the fire, whether it be open or in stoves, either well to wash their hands, or other frozen parts, in very cold water, or else to rub them well with snow it self. And this brings into my mind, that I sometimes endeavoured to find by trial, what beef long exposed to freeze and differing thawed would teach me, by way of confirmation of this tradition; but being then obliged to unseasonable removes from the place, where I made my trials, they did not for that reason afford me the satisfaction I desired; but meeting with an intelligent person, that had been an housekeeper in *Muscovy*, and enquiring of him, whether he had observed any thing about this matter, he told me, that having once had two very large cheeses frozen, he thawed one of them in water, and the other in a stove, but found, that thawing in water was much the better way of the two. And I was well pleased to be answered by him, that the cheese, thawed in water, did soon acquire therein a crust of ice.

Gulielmus
Fabricius
Hildanus,
de Crange,
& Sphacelo,
chap. 10.

14. But more memorable is that relation, which I remember I have read in the experienced chirurgion *Fabricius Hildanus's* treatise of *Gangrenes*, where he relates from credible testimony, how the whole body of a man was successfully thawed, and, which is more strange, cased all over with ice, by being handled as our eggs and apples were. His own words, because the narrative may prove of some use, I shall subjoin, and they are these: *Narravit mihi vir quidam nobilis & fide dignus, se, cum eas regiones peragraret, incidisse aliquando in viatorem secundum viam frigore rigidum, ac pene mortuum, quem plastro suo impositum, cum deduxisset in diversorium, hospes illico demersit in frigidam, quo facto undequaque ita erupit gelu, ut ipsius corpus glacie, seu ferreo thorace contactum conspiceretur. Tum quoque propinatum illi agebat cyathum ampliore hydromelitis, quo illi seu potu ordinario utuntur, addito pulvere cinnamomi, caryophyllorum, & macis, unde sudor in lecto provocatus est; atque ita egrum ad se rediisse amissis duntaxat manuum & pedum extremis articulis. Hinc intelligimus hanc methodum sanandi congelatos veram ac tutam esse, ac eam etiam probat summus philosophus, qui regiones illas frequentavit, &c.*

15. THE experiment delivered at the beginning of this title, (of speedily producing ice on the outside of frozen eggs and apples, by immersing them in cold water) I take to be one of the two or three most illustrious, I have hitherto met with about congelation; and as likely as any to assist us to investigate the causes of it. But though the phænomena seem very favourable to their hypothesis, that suppose congelation to be effected by the ingress of frigorifick atoms into the water or other bodies to be congealed; yet (for some reasons) I shall not here offer to draw any speculative inference from the experiment, contenting my self to have here, and at the beginning of this section, hinted in *transitu* the hopefulness of its proving luciferous.

16. BUT I remember, that the title of this section promises something concerning the preservation and destruction of other inanimate bodies, as well as eggs and apples, by cold; but as that intimated promise makes the last part of the title, so what I have to deliver on this subject must not be expected to be other than the last part of this section. And indeed to be able to add much to that little, which is generally known about this subject, I should either have lived in colder climates than ours, or have had, which I had not, the opportunity of making experiments, that require length of time. And therefore I shall only propose a general consideration about this matter, and subjoin a few of the chief observations I have met with in navigators or others about it. That then, which I would premise in general, is only this; that whether bodies be frozen by the ingress of frigorifick atoms, which by their intruding in swarms can scarce avoid discomposing the texture of the body; or whether it be made by the recess of some matter, that did, before congelation, more strongly agitate its parts;

parts; which way soever, I say, freezing is effected, it is manifest, that the nature of a frozen body is, at least for the time, much altered; and therefore we thought fit to place it among our general articles of inquiry about cold, what the effects of it may be as to the conservation or destruction of the texture of bodies. But as for the duly prosecuting this inquiry, we do, as we lately intimated, want the time and convenience, we judge needful for such a work; the matter seeming to require, that it be watchfully and considerately managed, and that both the nature of particular bodies, and the differing degrees of cold, and the differing times, wherein the condition of the exposed body is estimated, be taken into consideration. For we find, that a moderate degree of cold preserves many bodies, and that glaciation destroys, or at least prejudices most others (probably by discomposing or vitiating their texture) when they come to be thawed, though whilst the frost is in them, it keeps almost all bodies from disclosing any putrefaction.

17. THIS being the general consideration I intended to propose, it remains, that I add out of credible writers, or other relaters, some observations to illustrate and confirm the chief particulars comprehended in it.

AND first, that a moderate degree of cold conduces much to the preservation of the greatest part of inanimate bodies, is a thing vulgarly taken notice of and acknowledged. And I do not readily remember any instances, that manifest, that any degree of cold, though more than moderate, provided it fall short of freezing the bodies exposed to it, does spoil them. *Regii Mutinenses* (says the industrious *Bartholinus*) *nivem hoc sine arte compactam servant in cellis nivariis, in quibus fervente aestate vidi carnes mattatorum animalium à putredine diu se conservasse.* The next thing I shall mention to our present purpose, is a memorable passage in captain *James's* voyage; which shews, that so great a degree of cold, as may be supposed to have reigned in his ship, that was frozen up all the winter in one of the coldest regions of the world, was not great enough to spoil the meat and drink, that had laid all that time under water, because it seems by the story, that they were not actually frozen; the words of his journal are these: "By the ninth of *May* we were come to, and got up our five "barrels of beef and pork, and had four butts of beer, and one of cyder, which "God had preserved for us: it had lain under water all the winter; yet we could "not perceive, that it was any thing the worse." Which is the more remarkable, because of what we shall note by and by, both out of other books, and even out of this, about what became of a stronger liquor than beer, once brought to glaciation; and it seems our navigator found cold, if extremely intended, so destructive a thing, that he thought fit to take notice in his journal, that even a cable having lain under the ice all the winter, was not in *June* found a jot the worse.

Barthol. de
usu nivis,
p. 80.

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18. AND it seems by a passage in *Simlerus's* account of the *Alps*, that even intire bodies may be very long preserved by snow, and, as far as I can guess by the story, without glaciation. *Refert* (says *Bartholinus*, speaking of him) *in Rhetis apud Rinwaldios, nivium è monte ruentium moles sylvam & proceras abietes dejecisse; accidisse etiam Helvetio militiæ per Alpes iter faciente, ut 60 homines & plures eadem nivis conglotatione opprimerentur. Hoc igitur nivium tumultu sepulti, ad tempus æstatis delitescunt, quo soluta nonnihil nive decidua, corpora mortua inviolata patent, si ab amicis, vel transcurrentibus quaerantur. Vidimus ipsi triste hoc spectaculum, &c.*

Barthol. de
figura nivis,
pag. 79.

19. SECONDLY, I could alledge many instances to shew, that many, if not most inanimate bodies, (I say inanimate, because of the gangrenes and sphacelations that often rob living men of frozen toes, noses, and sometimes other parts) if they be actually frozen, will not disclose any putrefaction, whilst they continue in that state.

Nor is this much to be wondered at, since whether he will suppose, that in glaciation the moist and fluid parts are wedged in by intruding swarms of frigorifick atoms, or that those restless particles, that were wont to keep the body fluid or soft, are called forth of it, be the cause of glaciation; which soever of these two ways we pitch upon, we must in frozen bodies conceive an unwonted rest to be produced of those moveable particles, whose internal commotions, and disorderly coalitions and avolutions, are either the causes or the necessary concomitants of corruption.

20. ON this occasion I remember, that meeting with a knowing man, whose affairs stopped him during the winter upon the coasts of Sweden and Denmark, being desirous to learn of him, how long they could in those colder climates preserve in winter dead bodies unburied, and yet uncorrupted, he told me, he had opportunity to observe, that though the frost lasted, as it usually did in that season, three or four months together, or longer, the bodies might without any embalming, or other artificial way of preservation, be kept untainted by the bare coldness of the air. Of bodies lasting long unputrified in ice, navigators and others have afforded us several instances; but we will mention two, because they contain something more remarkable than the rest. The one is thus delivered by *Baribolinus*: *Notandum, corpora occisorum hyeme eodem positu, eademque figurâ permanere rigidâ, quâ ante eadem deprehensa sunt. Visum id extra urbem nostram, quum 11 Feb. 1659. oppugnantes hostes repellerentur, magnaque strage occumberent: alii enim rigidi iratum vultum ostendebant, alii oculos elatos, alii ore diducto ringentes, alii brachiis extensis gladium minari, alii alio situ prostrati jacebant. Imo ex mari gelato, primo vere resoluto, eques equo suo insidens integer emerfit, nescio quid manibus tenens.* The other instance is afforded us by captain *James's* Journal, and is by him thus delivered: "In the evening (of the 18th of May) the master of our ship, after burial
" returned aboard ship, and looking about her, discovered some part of our gunner
" under the gun-room ports. This man we had committed to sea at a good distance
" from the ship, and in deep water, near six months before. The 19th in the morning I
" sent men to dig him out, he was fast in the ice, his head downwards, and his heel
" upwards, for he had but one leg; and the plaister was as yet at his wound: in the
" afternoon they digged him clear out, after all which time he was as free from
" noisomeness, as when we first committed him to sea. This alteration had the ice
" and water and time only wrought on him, that his flesh would slip up and down
" upon his bones like a glove on a man's hand." But there is one pertinent particular more, which, if it be strictly true, is so very remarkable, that I cannot on this occasion forbear to annex it; which is, That according to the relation of the merchants of *Copenhagen*, that returned thither from *Spitzberg*, a place in *Greenland*, the extreme cold will there suffer nothing to putrify and corrupt, insomuch that buried bodies are preserved thirty years intire and inviolated by any rottenness.

21. THIRDLY, though whilst bodies continue frozen, the cold (as may be supposed) by arresting the insensible particles, from whose tumultuary motions, and disorderly avolutions corruption is wont to proceed, may keep the ill operations of cold upon the violated textures of bodies from appearing; yet when once that impediment is removed, divers bodies make haste to discover, that their texture was discomposed, if not quite vitiated by the excessive cold. I might alledge on this occasion, that I have shewn divers ingenious men by an experiment that I have taught in another
* treatise, that the change produced in the textures of some bodies by glaciation, may be made manifest even to the sight. For by freezing an ox's eye, the crystalline humour, which in its natural state is transparent enough, to deserve its name of crystalline, though not fluid enough to deserve the name of humour, lost with its former texture all its diaphaneity, and being cut in two with a sharp knife, appeared quite

Barthol.
de usu nivis,
p. 83.

Capt.
James's
travels,
p. 76.

Barthol.
de usu nivis,
c. 12.

* Of the
usefulness of
Experimental Philo-
sophy.

quite throughout very white. But for confirmation of this I shall rather add, that I remember, that the person formerly mentioned, that had made trial of the two cheefes, confessed to me, That, though that, which had been thawed in cold water, was very much the less spoiled, yet they were both of them manifestly impaired (and the other of them was so in its very consistence) by the frost, though the bulk of the cheefes was very considerable, and though they were both of them, of a more than ordinarily good and durable fort.

22. THE next thing I shall alledge to this purpose, is the observation of the *Hollanders*, even by such a degree of cold as they met with in *Nova Zembla*, before the middle of *October*, at which time their strong beer, by being partly frozen, had its texture so vitiated, that the reunion of its unfrozen to its thawed parts could not restore any thing near such a spirituous liquor, as it was before. "We were forced," (says *Gerat de Veer*, that wrote the story) to melt the beer, for there was scarce any unfrozen beer in the barrel, but in that thick yeast, that was unfrozen, lay the strength of the beer, so that it was too strong to drink alone; and that which was frozen tasted like water, and being melted, we mixed one with the other, and so drank it, but it had neither strength nor taste." And in the next month's journal he tells us, that their best beer was for the most part wholly without strength, so that it had no favour at all. But a more remarkable instance to our present purpose is afforded us by our countryman captain *James*, because it manifests the cold to have the same effect upon a much stronger and more spirituous liquor. "I ever doubted" (says he in his journal) that we should be weakest in spring, and therefore "had I reserved a tun of *Alicant* wine unto this time. Of this, by putting seven parts of water to one of wine, we made some weak beverage, which (by reason that the wine by being frozen, had lost his virtue) was little better than water."

Purch. Lib.
2. cap. 5.
sect. 2.
pag. 493.

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23. AND I remember, that a learned man, whom I asked some questions concerning this matter, told me, that in a northern country, less cold than *Muscovy*, he had observed, that beef having been very long frozen, when it came afterwards to be eaten, was almost insipid; and being boiled, afforded a broth little better than common water.

24. If I had not wanted opportunity, I should here subjoin an account of some trials, for which I made provision, as thinking them not absolutely unworthy the making, though extravagant enough not to be likely to succeed. For I had a mind to try, not only whether some plants, and other medicinal things, whose specific virtues I was acquainted with, would lose their peculiar qualities by being thoroughly congealed, and (several ways) thawed; and whether thawed hartshorn, of which the quantity of salt and saline spirit of such a determinate strength should beforehand be tried by distillation, would, after having been long congealed, yield by the same way of distillation the same quantity of those actual substances, as if the hartshorn had not been frozen at all. But I had also thoughts to try, whether the electrical faculty of amber, (both the natural, and that factitious imitation of it I elsewhere teach) and whether the attractive or directive virtue of load-stones, especially very weak ones, would be either impaired, or any ways altered by being very long exposed to the intensest degrees of cold within my power of producing. But to have named such extravagancies, is that, which I think enough, and others I fear may think too much.

25. YET some few things I shall subjoin on this occasion, because it will add somewhat not impertinent to the design of this treatise (which is to deliver the phenomena of cold) as well as countenance what I have been proposing; and those things are, that I can by very credible testimony make it appear, that an intense cold may have a greater operation upon the texture even of solid and durable bodies, than we in this temperate

temperate climate are commonly aware of. I shall not urge, that even here in *England* it is generally believed, that men's bones are more apt to break upon falls in frosty, than in other weather, because that may possibly be imputed to the hardness of the frozen ground. Nor, that I remember, when I was wont to make use of stone-bows, I found it a common observation, that in frosty weather the laths, though of steel, would, by the cold, be made so brittle, that unless extraordinary care were had of them, or some expedients were used about them, they would be apt to break. Nor yet, that an ingenious overseer of great buildings has informed me, that those that deal in timber and other wood, find it much more easy to be cleft in hard frosts, than in ordinary weather. These and the like instances I do, as I was intimating, forbear to urge, because these effects of cold are much inferior to those that have been met with in more intemperate regions.

26. AND to begin with its operation upon what we were last treating of, wood. Of *Charleton-island*, captain *James* has this passage about the timber, they employed upon their works: 'The boys (says he) with cuttle-axes must cut boughs for the carpenter; for every piece of timber, that he did work, must first be thawed in the fire.' And a little before, he tells us, that even when they found a standing tree, they must make a fire to it to thaw it, otherwise it could not be cut.

27. AND I remember, that two several persons, both of them scholars, and strangers to one another, that had occasion to travel as far as *Moscow*, assured me, that they divers times observed in extreme frosts, that the timber-work (whether the boards or the beams) of some houses, which, according to the custom of that country, were made of wood, and perhaps, not well seasoned, would, by the operation of the cold, be made to crack in divers places, with a noise, which was surprizing enough to them, especially in the night.

28. I REMEMBER also, that a physician, who lived for some years in one of the coldest plantations of the *West-Indies*, related to me, that he had observed the bricks, he had employed about building, to be very apt to be spoiled by the long and vehement frosts of the winters there; where he likewise said, that it was a usual thing for the houses builded of brick, to decay in fewer years by far, than here in *England*; which he said was generally, and, as he thought, truly imputed to the excessive cold, which made the bricks apt to crumble, and moulder away. But though I dare not lay much weight on this observation, unless I knew, whether the bricks were sufficiently burned, and free from pebbles, calcinable by the heat that burned the bricks; yet we must not deny, that extreme colds may be able to shatter or dissolve the texture of as close and solid bodies as bricks, especially if the aqueous moisture be not sufficiently driven away; if we will admit, what I remember I have mentioned in another treatise, out of a very learned and credible author, of the power, that a freezing degree of cold has had to break even solid marble. And much less shall we doubt the possibility of what the physician related, if we will not reject the testimony of the learned *Olaus Wormius*, according to which, instruments made even of so hard a metal as brass are not privileged from the destructive operations of some degrees of cold. For, *Ex ære facta opera* (says he in his curious *Museum*) *vi frigoris quandoque rumpuntur, quod tamen pauci credunt, id tamen expertus est Eratosthenes, & nostras Johannes Munckius in difficillimo suo itinere, quo per fretum Christianum transitum in mare Australe invenire moliebatur.* To which, perhaps most writers would, if they met with it, add this passage out of the Dutch-mens voyage to *Nova Zembla*: 'The 20th (of October) it was calm sunshiny weather, and then again we saw the sea open, at which time we went on board, to fetch the rest of our beer

' out

‘ out of the ship, where we found some of the barrels frozen in pieces, and the iron hoops, that were upon the jofam barrels, were alfo frozen in pieces.’ But though this testimony feems to prove, that extreme cold may break even iron itfelf, and though poffibly fuch an affirmation might in the general not be erroneous, yet I fhall forbear to draw that inference from this paffage, becaufe I fufpect, that fince the irons, that were broken, were hoops, and fince it feems probable by the ftory, that there were barrels not hooped with iron broken alfo by the fame froft; the breaking of the hoops may have been the effect, not of the violence of the cold, as acting immediately upon the iron, but of the liquor in the veffels, which being, by the cold that froze it, turned into ice, was fo forcibly expanded, as to burft whatever oppofed its dilatation, according to what we fhall have occafion in its due place more fully to deliver.

An Appendix to the VIth title.

INQUIRING of the formerly mentioned phyfician to the Ruffian emperor, what experience teaches about fome of the matters treated of in this (fixth) title, in thofe cold climates, where the effects of freezing are more notable; he told me, that the tradition (mentioned above, touching the fafeft way of thawing) is in *Mufcovy* generally received; and that it is ufual for men, that have their cheeks and nofes frozen, to rub them well with fnow, and efcape unharmed; whereas if they go immediately into their ftoves, they often lofe the tops of their nofes, and introduce into their cheeks a kind of paralytick diftemper, or benumbednefs, that they cannot get rid of in many months.

AND having alfo inquired of the fame ingenious perfon, whether wine frozen, and then permitted to thaw, till the unfrozen liquor had quite refolved the ice, was not thereby fpoiled by having its texture vitiated, he answered, that in very ftrong claret-wine he found the colour fcarce at all deftroyed, nor the liquor otherwife much impaired; but that in weaker claret-wine the colour was fpoiled, and the liquor was otherwife much the worfe. But note, that in the French wine there remained a third part or more unfrozen, fo that it feems not to have been expofed to near fo extreme a cold, as that of the Hollanders, or of captain *James*; and that phyfician likewise told me, that of fome very ftrong beer, that he had in great part frozen, the ice had fome tafte of the hops, but was difpirited like phlegm.

HAVING inquired how long dead bodies would keep, he told me, that if they were thoroughly frozen, they would be preferved incorrupted till the thaw, though that perhaps might not happen within four or five months after the death of the man. He added, that he had the venifon of elks fent him unfalted, and yet untainted, out of *Siberia*, (which is fome hundreds of leagues diftant from *Mofcow*) and that beef and other flefh well frozen, would keep unputrified for a very long time. And when I asked, whether the freezing did not impair it, he answered, that with long keeping it congealed, it will grow very dry and be impaired in tafte, and will not make fo good broth as meat that was never frozen. And he further told me, that in cafe frozen meat were leifurely thawed, it would be far the lefs impaired, and might be well roasted, but if before it was thawed, it were laid down to the fire, it would not ever be well roasted, and would eat very fcurvily: and though a fhoulder of mutton, for inftance, were kept very many hours turning before the fire, yet it would continue raw in the middle.

HAVING inquired about the rubbing bodies with fnow to unfreeze them, he told me (agreeable to what I noted him to have faid above) that he had feen feveral perfons, that had been frozen, and that when a man is told, that he is frozen, and having asked whereabouts (for the party himfelf ufually knows it not) is informed, that

that it is in this, or that place, which is commonly the nose or the upper part of the cheek, or perhaps the tip of the ear; he usually rubs the part very well with snow, and lets it thaw by degrees; else, if without that preparation he should go immediately into the stove, he would be in danger to lose his nose, or other frozen part. The doctor added, that they use to rub the frozen meat and fish with snow, and that he once examined a man, who in his youth had been frozen all over, and informed the doctor, that having had occasion in a journey to quit his sled for a while, and do some exercise, that had almost made him sweat, being careless of himself, when he returned to the sled again, he was frozen all over, and had so died, had not the company by accident taken notice of him, and by rubbing him over with snow, and by the use of the like means recovered him again; but he told the doctor, that by this whole accident he was put to no pain, save that when he came to himself again, he felt such a pricking all his body over, as men are wont to find in an arm or leg benumbed, by having been long leaned upon.

WHEN I asked, whether the sharpness of the cold did not work upon the stones, he answered, that as to flints he could not tell; but as to other stones, and such as are oftentimes used for building, the violence of the cold made them frequently moulder into dust. And to satisfy my curiosity about the effect of cold upon wood, he told me, that he had very often in the night, especially when their keen frosts were unaccompanied with snow, heard the trees cleave and crack with very great and sometimes frightful noises; and that the outside of the fir-trees, that were laid upon one another in their buildings, and was exposed to the air, would do the like; and that he had often seen the gaping clefts sometimes wide enough to put in his fingers, which would remain in the trees, and in the fir-wood, till the thaw, after which they would pretty well close of themselves.

T I T L E VII.

Experiments touching the expansion of water, and aqueous liquors, by freezing.

1. **T**HAT water and other liquors are condensed by cold, and so much the more condensed, by how much the greater the degree of cold is that condenses them, has been for many ages generally taught by the schools, and taken for granted among men, till of late some more speculative than the rest, have called it in question upon the account of the levity of ice; since which, I have met with two modern writers, that have incidently endeavoured to prove, that ice is water, not condensed, but rarified by the intumescence of water exposed to freezing in vessels fitly shaped.

THE attempts of these learned men putting me in mind of what I had tried to this purpose, when I was scarce more than a boy, invited me to consider, that by the usual ways of glaciation, such as these ingenious men employed, the experiment is wont to meet with a disaster, by the breaking of the glasses, which not only makes the event liable to some objections of theirs, that befriend the common opinion, but (which is more considerable) hinders them from judging what this expansion of water, that is made by freezing, may amount to. Wherefore we will now set down what we have done to ascertain (and yet limit) the experiment, as also to advance it further.

2. **W**HEREAS then these two learned men, we have been mentioning, do so expose the water to freeze, that it is turned into ice at the top as soon as elsewhere; the inconveniencies of which way, we have already noted; we, by freezing the water, as we have formerly taught from the bottom upwards, can easily preserve our glasses intire, and yet turn the whole contained water into ice: so that if according to this way you so place a bolt-head or a glass-egg, in whose cavity the water ascends to the height

height of an inch, or thereabouts, within the stem or shank, in a mixture of ice, or snow and salt, as that the water is first turned into ice at the bottom and sides, and not till the very last at the top, you shall manifestly see, that the ice will reach a good way higher in the neck, than the fluid water did, and that upon a gentle thaw of the ice, the water it returns to, will rest at the same height in the stem, to which it reached, before it was exposed to be frozen.

3. WE have likewise used other ways unspoken of by the lately mentioned writers, to evince, that water is expanded by being frozen; at first, that we took a strong earthen vessel of a cylindrical form, and filling it with water to a certain height, we exposed it unstopped, both to the open air in frosty nights, and to the operation of snow and salt, and found that the ice did manifestly reach higher than the water did, before it was congealed.

BESIDES, if a hollow pipe or cylinder, made of some compact matter, be stopped at one end with wax, or some things else, which it may be more easy to drive out, than to burst the cylinder; and if at the other end it be filled with water, and that orifice also be stopped after the same manner; this pipe, suspended in a sufficiently cold air, will have the included water frozen, and by that change, if the experiment have been rightly made, the water will upon congelation take up so much more room than it did before, that the above-mentioned stopples, or at least one of them, will be thrust out, and there will be produced a rod of ice a good deal longer than the pipe, at each of whose ends (or at least at one of them) a cylindrical piece of ice of a pretty length may be broken off, without meddling with the pipe, or the ice that fills it.

DIVERS other ways of proving the same truth might be here alledged, but that, though these were not, as they are, sufficient, the matter would yet be abundantly confirmed by divers of the experiments, that will here and there come in more opportunely in the following part of this treatise.

4. BUT here it will not be altogether impertinent or unseasonable to take notice, that not only those school-philosophers, who have considered the breaking of well-stopt glasses in frosty weather, (an accident but too frequent in apothecaries shops, and laboratories) but divers modern virtuosi, are wont to ascribe the phænomenon to this, that the cold of the external air, contracting the air and liquor within, the ambient air must break the sides of the glass to fill that space, which being deserted upon the condensation of the included air, the liquor would otherwise leave a vacuum abhorred by nature; and even those few moderns, that are loth to ascribe this phænomenon to nature's abhorrency of a vacuum, either not being acquainted with the weight of the air, know not what probable account to give of it; or if they acknowledge that weight, are wont to ascribe it to that, and to the great contraction of the internal air, made by the cold of the external.

5. BUT as for the Peripateticks, the above-mentioned experiments sufficiently evince, that in many cases, it is not the shrinking, but the expansion of the liquors contained in the stopt vessels, that occasions their bursting; and therefore in these cases, we need not, nor cannot fly to I know not what *fuga vacui* for an account of the phænomenon. And whereas it may be objected, that even glasses not half full of distilled waters, if they be exactly stopt, are often broken in apothecaries shops: I answer, That neither in this case do I see any need of having any recourse, either to the *fuga vacui*, or to the weight of external air; for even here the expansion of the freezing liquor may serve the turn; for in such inartificial glaciations the liquor begins to freeze at the top, and there generated, fastening it self (as on other occasions we declare) very strongly to the sides of the glasses, contiguous to its edge, as the liquor freezes deeper and deeper, this crust of ice increases in thickness and strength, so that

the water is included, as in a vessel hermetically sealed betwixt this ice at the upper part, and the sides and bottom of the glass every where else; and consequently, the remaining water being incapable of congelation without expansion, when the ice is grown strong enough at the top, to make it easier for the expansive endeavour of the freezing water to crack the sides or bottom of the glass, than to force up that thick cake of ice, the vessel will be broken, how much soever there be of it empty above the surface of the ice. And this conjecture may be confirmed by these two particulars: the one, that when water is frozen in a broad vessel, which is too strong to be broken or stretched by the frost, the surface of the ice contiguous to the air will be convex or protuberant; because, that though the glaciation began at the top, the thickness and compactness of the vessel makes it easier for the expansive endeavour to thrust up that cake of ice in those parts of it, that are the remoter from the sides, whereunto they are strongly fastened, than to break so solid a vessel.

6. THE other particular is afforded us by that experiment of ours, (mentioned in the fifth title foregoing) wherein if a vessel half full of water be made to freeze, not first at the top, but at the bottom, that liquor may be turned into ice without danger to the glass. But we will now add an experiment, on whose occasion we have set down those considerations. For being inclined to think, that the spring of the air, shut up in a vessel stopped, will preserve it expanded, or at least keep it from considerably shrinking, notwithstanding a very great degree of cold, in case the vessel be strong and close enough to fence it from the pressure of the external air; we conjectured that the bare weight of the outward air, added to the refrigeration of the included air, would not be sufficient to break much weaker glasses, than those we have been speaking of. And therefore partly to satisfy some ingenious men, that this conjecture made me dissent from, and partly to shew the Peripateticks, and those that adhere to them in the question under consideration, that either the cold alone cannot always, as they teach us, contract the air, or that, if it do, the breaking of well-stopped glasses in frosty weather is much fitter to evince, that there may be a vacuum, than that there can be none, we made the following experiment.

7. WE took three glass-bubbles of differing shapes and sizes, which we caused to be blown with a lamp, that, to make the experiment very favourable for our adversaries, we might have them much thinner, and consequently, weaker than those glasses, that are wont to be made use of to keep liquors in, and which, notwithstanding, are wont to be broken, though they be not full, by the frost.

THESE bubbles, when the air was at a convenient temper within, were (as easily they might be) nimbly sealed up with care, to avoid the heating of the air in them; and being afterwards exposed sometimes to the air it self in very frosty weather, and sometimes to that greater cold, which is produced by the placing them in a mixture of snow and salt, we could not nevertheless find, that any one of three was at all broken or cracked; so that in case the included air were condensed into a lesser room, the space it deserted may be concluded empty, or else it will hardly appear, what necessity there can be, that nature should break, as the Peripateticks pretend, very much stronger glasses in apothecaries shops, to prevent a vacuum.

8. HAVING shewn, that water it self acquires a considerable expansion by cold, we will next shew, that aqueous bodies, or those that abound with waterish parts, do divers, if not all of them, the like.

WE took eggs, and exposing them to a sufficient degree of cold, we observed, that when the contained liquors were turned into ice, they burst the shells asunder; so that divers gaping cracks were to be seen in them, as long as they continued frozen.

9. MILK,

9. MILK, urine, Rhenish-wine, and good spirit of wine, being set to freeze in distinct glass eggs, neither of the three former liquors was observed to subside before it began to freeze. The event in sum was, that the urine was much longer, than either of the two other liquors, before it began to swell, but rose to a far greater height, than they, afterwards. The wine did not leave the mark above an inch beneath. The milk ascended about two inches, and the urine by guess six or seven.

10. A STRONG solution of *Dantzick* vitriol being put into a cylindrical pipe, sealed at one end so, that the liquor filled the pipe to the height of about six or eight inches, being frozen with snow and salt, the congealed liquor grew very opacous, and looked as if it had been turned or shot into a vitriol, save a little, that remained fluid, and transparent near the bottom. And this ice, as appeared, rose considerably higher than the liquor did before congelation.

It were perhaps worth trying, whether or no even several bodies of a stable consistence, and durable texture, might not be found to receive some, though less manifest dilatation by excessive cold. And methinks those, who attribute glaciation to the plentiful ingress of frigorifick atoms into bodies, should by their hypothesis have been invited to make some trials of this kind, since we see, that the invisible moisture of the air against rainy weather does seem manifestly enough to alter the dimensions of doors, window-shutters, and other such works made of wood not well seasoned. And even without supposing the truth of the Epicurean hypothesis, if we consider, that in bread, though we are sure, that much more water was added to the meal, or flower, than was exhaled in the oven, yet there appears not the least drop of water distinct in the concrete, and that hartshorn, sponges, and many other bodies, that seem very dry, will afford by distillation good store of phlegm or water, and more than can probably be ascribed to any transmuting operation of the fire: if, I say, we consider these and the like things, it may seem worth while to try (which I want the conveniency to do) by accurate measures, whether the invisible and interspersed water, its comminution notwithstanding, will not upon freezing swell the body, that harbours it. And I would the more gladly have been satisfied in this, because I hoped it might help me to unriddle a strange phenomenon, afforded us by the narrative of the Dutchmen's voyage to *Nova Zembla*, wherein they relate, 'that the cold was so great, that their clock was frozen, and would not go, though they hung more weight upon it than before:' so that they were fain to measure their time by hour-glasses. For though this odd effect might be suspected to proceed from some little icicles sticking to some of the wheels, or the line, in regard they not far off tell us, that the steams of their bodies, and other things within their close house*, did so fasten themselves to the walls, to the roof, and even to their cabins, as to line them with ice, of no less than two fingers thick; yet besides that it cannot be probably supposed, that they, who had so great need of their clock, during the tedious absence of the sun for many weeks together, should not all the winter long be aware of this; besides this, I say, I find, that in captain *James's* wintering at *Charleton*, his clock and watch were so frozen too, 'that they could not go, notwithstanding they were still kept by the fire-side in a chest, wrapt in cloths.' So that in case it appear, that, according to what we formerly noted out of *Wormius*, the frost can get into metals, it can also distend them, and other stable bodies: we might conceive, that the stopping of the clocks might proceed from the stiffness, or the swelling of the line, to which the weight was

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* It froze so sore within the house, that the walls and the roof thereof were frozen two fingers thick with ice, and also in our cabins, where we lay all those three days, while we could not go out. *Gerat de Peer* in his third Voyage.

fastned, or a swelling even of some of the wheels, or other metalline parts of the clock, that may spoil the necessary congruity between the teeth, &c. as I have tried, that some parts of an iron instrument, I caused to be made, would by no means fit one within another, when expanded by much heat, (and though cold be the cause of the expansion, the effect may be the same) though at other times they would. And if we knew, whether springs lose any thing of their elasticity by the violence of the cold, we might thence also be assisted to guess, whether the frost's operation upon the spring of captain *James's* watch (for he mentions that, as distinct from his clock) might contribute any thing to the forcing it to stand still. But these are bare conjectures, from which I will therefore pass on to the following section.

T I T L E VIII.

Experiments touching the contraction of liquors by cold.

1. **B**UT notwithstanding all the former experiments, we must not conclude universally, that all liquors are disposed to be expanded by cold, neither by a moderate degree, nor even by so intense a degree of it as suffices to freeze or congeal the liquors exposed to it. This we have tried, not only in spirit of wine, aqua fortis, oil of turpentine, and divers other liquors, that we could not bring to freeze, but also in oil congealed by the vehemence of cold; so that as to the change of dimensions produced in liquors by cold, there must be a great difference allowed betwixt water and aqueous liquors on the one side, and oil and divers other liquors, that are some of them of an oleaginous, and some of a very spirituous, or very highly corrosive nature, on the other side. Nor have we yet made trials enough to reduce this matter to a certainty. For though we could not bring some strong saline spirits, nor the most of chymical oils to freeze; yet in some our attempts succeeded not ill. But I remember not, in any liquor we could by cold produce any sensible expansion, but rather a manifest condensation, unless we could bring it actually to freeze.

2. THE trials we made of the efficacy of cold to condense liquors, were many; but it may, for the present, suffice to set down two or three differing ones, that occur to us in our collections.

To the entry of the experiment lately recited, of the expansion of milk, urine, and the Rhenish wine, there are subjoined these words:

[But the egg, that held the spirit of wine, though it were much smaller than we usually employ, and fitted with a proportionably slender stem, and though it were kept divers hours partly in ice and salt, and partly in snow and salt, yet it froze not at all, but subsided by degrees below the first mark to the quantity of $\frac{3}{4}$ of an inch in the stem; and though it afterwards seemed to rise a little, yet it never swelled up again to the said first mark.]

3. WE took a round bolt-head of about in diameter, and poured in mercury till it reached a pretty way into the neck, which was purposely drawn more slender than ordinary; and having, without approaching it to the fire, freed it from some of the larger bubbles of air, that appeared at the sides, we put it into a mixture of ice and salt, where the cold so wrought upon it, that watching it attentively, we could discern not only its having moved, but its motion downwards, which it continued (though not visibly in the progress, as at the first) till it was subsided in the neck two inches or better, which was far more than could be attributed to the contraction of any sensible aerial particles, though they had lost not only the 30th part of their dimensions,

dimensions, as we have sometimes observed of the air, but had been contracted to a point; and we observed too, that the quicksilver once thus in frigidated, though not frozen, retained some of the acquired cold, for many hours after, as appeared by its keeping below the mark of its first height, though we had kept it all night in a warm room.]

[4. WE took a small egg with a proportionably slender stem, into which we poured common oil, till it rose a pretty way (but not much) above the oval part of the glass; then having put a mark upon the station of the liquor, we placed the vessel in snow and salt, and observed it not to swell as other liquors, but to subside, with cold; till being quite frozen or congealed, it appeared to be shrunk about an inch or more beneath the mark; then being thawed, it swelled again to the mark.]

5. THE experiment was repeated the second time, with not much worse success; but we found, that if the glass were removed out of the snow into some place near the fire, the hot air would not only thaw it, but so rarify it, as to make it ascend above the mark. A third time we sealed up the same oil in the same glass, and repeated the experiment, with like success to that we had the second time; and that the frozen oil was really condensed, we found, because it would sink in oil of the same kind, cold, but unfrozen; and this, notwithstanding divers bubbles, which we observed usually to be made about each lump of congealed oil, that we cast in, upon its beginning to sink in the fluid oil. This we tried, both with oil well congealed (or if another word please better, incassated or curled) by snow and salt, and with oil less congealed, frozen by the bare cold of the ambient air; but this latter seemed, to fight, to sink more slowly than the other, and being less congealed and ponderous, yet would not lumps of the mass of oil sink or continue immersed. I say, not in common water, but in sack or claret wine; and if thrust down into either of these liquors, they nimbly enough emerged.

6. WHETHER or no chymical oils, though, like expressed oils, they shrink with a moderate degree of cold, would by congelation be, like them, contracted; or like aqueous liquors, expanded, we could not satisfy ourselves by experiment, because we were unable to advance cold to a degree capable of bringing such oils to congelation; only we had thoughts to make a trial with oil of aniseeds, distilled with water in a limbeck, in regard, that though it be a very subtil liquor, and, as chymists call it, an *essential* oil; and though in the summer-time, and at some other seasons (if the weather be warm) it will remain fluid; yet in the winter, when the air is cold, it will, if it be well drawn, and genuine, easily enough lose its fluidity; and therefore we thought it might do well to pour some of it, in moderate weather, into a conveniently shaped glass, and then to freeze it externally by the application of ice and salt, that we might observe, whether upon congelation it would shrink or be expanded. And accordingly, though we were not provided with any quantity of this oil, yet in weather, that was not sharp, we did, by the help of some ice, which we procured, when the season made it a rarity, surround a glass pipe filled with fluid oil of aniseeds, and found, though the pipe were but short, yet the inclosed substance, when it had lost its fluidity, had considerably lost of the height, which it reached to before.

7. AND because the empyreumatical oils, that are driven out of the retorts by somewhat violent fires, seemed to be of a nature differing enough from those essential oils (as artists call them) which are drawn in limbecks by the help of water as well as fire; and because we observed, that some of the firmer oils may be used in physick, in much larger doses than it is thought safe to give the latter in: conjecturing from
hence,

hence, that probably empyreumatical oils may be less hot, and so less indisposed to congelation, we thought fit to make trial (no body else in probability having done it) whether the cold in our climate could be brought to freeze these oils, and whether it would expand or condense them. Wherefore exposing, in conveniently shaped vessels, some good oil of guaiacum, that was diaphanous enough, though very highly coloured, to the greatest cold we could produce, we attempted, but in vain, to deprive it of its fluidity; all that we were able to effect, being to make it very manifestly shrink.

TITLE IX.

Experiments in consort, touching the bubbles, from which the levity of ice is supposed to proceed.

1. **S**INCE the first thing, that made the moderns suspect, that water is expanded by freezing, is the floating of ice upon water; it will not be amiss, for confirmation of that argument, to take some notice of the levity of ice in respect of water. This is best observed in great quantities of ice; for whereas in small fragments or plates, the ice, though it sink not to the bottom of the water, will oftentimes sink so low in it, as scarce to leave any part evidently extant above the surface of the water, in vast quantities of ice, that extancy is sometimes so conspicuous, that navigators in their voyages to *Iceland*, *Greenland*, and other frozen regions, complain of meeting with lumps, or rather floating rocks of ice, as high as their main-masts. And if we should meet with cases, wherein we might safely suppose the ice to be as solid as entire pieces of ice are wont to be with us, and not to be made up of icy fragments cemented together, with the interception of considerable cavities filled with air, it would not be difficult for any, that understands hydrostaticks, to give a pretty near guess at the height of the extant part, by the help of what we lately observed of the measures of water's expansion, and by the knowledge of the immerfed part; which supposing, that the ice were of a prismatical figure, and floated in an erected posture, would, in fresh water, amount to about eight or nine times the length of the part of the prism superiour to the surface of the water.

2. **B**UT because perhaps the great disparity in the degrees of cold, whereby water is in this, and in those gelid climates turned into ice, may breed a difference in the expansion of the frozen water; and because some other circumstances may be needful to be taken into consideration, about the height of floating ice above water, and these will be more properly taken notice of under the following title; I shall only upon this head (*of the levity of ice*) subjoin the ensuing transcript of one of our notes concerning that subject.

[We found, that pieces of ice, clear and free, for aught the eye could take notice of, from bubbles, would not be made to sink in spirit of wine once distilled from brandy, and it floated likewise in strong spirit of wine drawn from quick-lime; but if the spirit of wine were well warmed, such ice, as I mentioned, would sink in it, though as it grew cold, the same ice would slowly ascend, and sometimes remain for a while, as if it were suspended without sensibly rising or falling. But all this while the ice, thawed apace in the water, whereinto it was dissolved, did manifestly seem to run down like a stream through the lighter body of the spirit of wine, the diversity of the refractions making this easy to be taken notice of; yet common water, though heated as hot as I could endure to hold the glass in my hand, would not let the fragments

fragments of the same parcel of ice sink into it; but in oil of turpentine, and in thrice rectified spirit of wine, the ice would sink like a stone.]

3. THAT the levity of ice, in respect of water, proceeds from the bubbles, that are produced in it, and make the water, when congealed, take up more room than when fluid, has scarce been doubted by any, that has considered the texture of ice, as well as taken notice of its levity. But if this be the true and only reason, we may conjecture, that there must be great store of bubbles in ice, extremely minute, and undiscerned by the naked eye. For though in very many parcels of ice, the bubbles are as well conspicuous as numerous, inasmuch that they render the ice whitish and opacous, yet we have observed, that other pieces would swim, which yet were of an almost crystalline clearness. And therefore we thought fit to look upon some clear pieces of ice in a microscope, and we shall subjoin the event, because that when we beheld some of this ice in one of our microscopes, which has been counted by several of the curious, as a good magnifier, as perhaps any is in the world, we could not discover such store of bubbles, as it seemed there should appear upon the supposition, that the adequate cause of the levity and expansion of frozen water is but the interspersation of such bubbles.

THE observations I have been mentioning, I find thus set down among my notes.

[A PIECE of ice, that to the eye looked clear like crystal, being put into the great microscope, appeared even there free from bubbles; and yet the same piece of ice being presently removed, and cast into common water, would swim at the top, and, if it were forcibly ducked, would swiftly enough emerge.

ANOTHER piece of ice, that to the naked eye was not so clear as the former, appeared in the same microscope to have store of bubbles, some of them appearing there no bigger than a small pin's head, and some of them being yet lesser, and scarcely visible in the microscope itself.]

AND here, because it seems a considerable doubt, and well worth the examining, whether or no water, when frozen into ice, grows heavier or lighter, not in reference to such water as it was generated of, (since it is evident, that upon that it will float) but more absolutely speaking, we judged it not amiss to examine this matter by an experiment; but we could not discover any difference between the weight of the same parcel of water fluid and frozen, as will appear by the ninth paragraph of the experiment to be a little beneath recited.

BUT since that, whether or no we allow any other cause, together with the bubbles, to the levity of ice, it seems a thing not to be doubted, that its expansion and lightness is mainly, if not only, due to the interspersation of bubbles, the generation of them seems to be one of the considerablest phenomena of cold, and the investigating by what cause those cavities are produced, and in case they be perfectly full, what substance it is that fills them, is none of the meanest enquiries, that should exercise the industry of a searcher into the nature of cold.

4. Mr. *Hobbes*, and some others seem to think, that the expansion of water by congelation, is caused by the intrusion of air, which constitutes those numerous bubbles wont to be observed in ice; we might here demand, why in case, that upon freezing there must be a considerable accession of air from without, when oil is frozen, it is, notwithstanding the ingress of this air, not expanded, but condensed: but because these conjecturers do not allow glass to be pervious to common air, we shall at present press them with this experiment, which we have divers times made.

WE took a glass-egg with a long stem, and filling it almost with water, we sealed it hermetically up, to exclude the pretence that some adventitious air might get in, and insinuate itself into the water, and yet such an egg being exposed to congelation, the frozen water would be manifestly expanded, and swelled by numerous bubbles, which oftentimes gave it a whitish opacity.

To which we may add, that new metalline vessels being filled with water, and carefully stopped, the liquor would nevertheless, when exposed to the cold, be thereby expanded, and turned into ice furnished with bubbles.

5. IF it be objected, that in the experiment of the hermetically sealed glass, the produced bubbles might come from the air, which being sealed up together with the water, might, by the expansion of that water, be brought to mingle with it: I answer, that this is very improbable. For 1. if the bubbles must cause the expansion of the water, how shall the water be at first expanded to reduce the air to a division into bubbles? Next, it is evident by the experiments we shall ere long relate, that the air, as to the body of it, retains its station above the water, and preserves itself together in one parcel, since it suffers a compression, that oftentimes makes it break the glass that imprisons it, which it would not need to do, in case it dispersed itself into the body of the water; for then there would appear no cause, why the air and water should after congelation require more room than they did before. 3. In this experiment we usually begin to produce ice and bubbles in the water, contiguous to the bottom of the vessel (that part being by the snow and salt first refrigerated) in which case there appears no reason, why the air, which is a thousand times lighter than the water, should against its nature dive to the bottom of the water: and if it were disposed to dive, why should we not see it break through the water in bubbles, as is usual in other cases, where air penetrates water? 4. In metalline vessels, and in glasses quite filled with water, before they are stopped, there is no pretence of the diving of the air from the top, there having been none left there. 5. And lastly, if all the bubbles of ice were made by, and filled with true air descending from the upper parts of the vessels, and only dispersed through the waters; then, upon the thawing of this ice, the air would emerge, and we might recover as much of the real air as would fill the space acquired by the water upon the account of its being turned into ice, which is contrary to our experience. And this argument may also be urged against any, that should pretend, (for I expect not to see him prove it) that though air, as numerous experiments evince, cannot get out of a sealed glass, yet it may in such a case as this, get into it. But we find upon trials, that the cavities of these bubbles are not any thing near filled with air, if they have in them any more air at all, than that little, which is wont, as we have elsewhere shewn, to lurk in the particles of water, and other liquors. And the making good of this leads us to the second enquiry, we were proposing about these bubbles; namely, whether or no their cavities be filled, and filled with air.

6. THE full resolution of this whole difficulty would be no easy matter, nor well to be dispatched with so much brevity as my occasions exact. For it would require satisfactory answers to more than one or two questions, since, for aught I know, it may lead us to the debate of those two grand queries, whether or no nature admit a vacuum, and whether a great part of the universe consist of a certain ethereal matter, subtil enough to pass through the pores, not only of liquors, but of compact bodies, and even of glass itself. We should also be obliged to enquire, whether or no air, I mean true and permanent air, can be generated anew, as well out of common water, as many other liquors, and whether it may be generated by cold itself; and perhaps we should be obliged to inquire into the *modus* of this production, and engage ourselves

ourselves in divers other difficulties, whose full prosecution, besides that they would as much exceed our present leisure, as abilities, seems more properly to belong to the more general part of physics, where such kind of general questions are fittest to be handled.

WHEREFORE we will now only consider this particular question, whether or no the cavities of the bubbles, wont to abound in ice, be filled with common air; and even this question, though it seem but one, comprizes two: for to resolve it, we must determine, whether there be any true air contained in those cavities, and whether in case there be, they be adequately filled with that air, (by true air I mean such an invisible fluid, as does permanently retain a spring like the common air.)

7. THE former of these two questions, I must confess myself not yet resolved about, my experiments having not hitherto succeeded uniformly enough to satisfy so jealous an observer. But yet I shall annex our trials, not only because the thing has not been, that we know of, so much as attempted by others, and our ways of experimenting, if they be duly prosecuted, seem as promising and hopeful (if the question be reducible to any certain decision) as perhaps will be easily lighted on; but because also we have, if we mistake not, resolved the second question, by shewing, that there is but a small part of true air contained in the bubbles of ice, whatever ingenious men, that rely upon probable conjectures, without consulting experience, have been pleased to believe to the contrary.

THAT the bubbles observed in ice cannot all be filled with the aerial particles lurking in the water, seems evident enough by the expansion of the water, and the quantity of space taken up by those bubbles; which how the interspersed, and formerly latent air, can adequately fill, unless the same parcel of matter could truly fill much more space at one time than at another, (which I take to be physically impossible) I do not yet apprehend.

BUT two ways of trial there are, which we employed to shew, that the icy bubbles are nothing near filled with true air, whether men will have that pre-existent in the water, or stolen in from without, or generated anew; the former of the two ways of trials probably arguing, that these bubbles proceed not *only* (for that they may proceed *partly*, we do not at all deny) from the air pre-existent in the water, and the latter concluding more generally, that but a small part of the icy bubbles are filled with genuine air.

8. AND I. we were invited to conjecture, both, that sometimes, or in some cases, the air latent in the water might contribute to generate icy bubbles, though it was unable adequately to fill them; and again, that sometimes or in other cases such bubbles would be almost as numerously generated, notwithstanding the recess of far the greatest part of that latent air, by the three following experiments taken *verbatim* out of our collections.

I. WE took fair water, and having kept it in the exhausted receiver of our pneumatical engine for a good while, till we perceived it not to send up any more bubbles, we presently transferred it into snow and salt, where it was long enough before it began to freeze; and then we observed, that the water did not swell near so much as common water is wont to do, and the ice seemed to have few or no bubbles worth taking notice of. But when I afterwards placed it between my eye and the vigorous flame of a candle, I could perceive, that it was not quite destitute of bubbles, though they were extremely small, in comparison of those, that would probably have appeared in ordinary water.

THUS far the first experiment; the second follows, which was made at another time.

II. THE water, that had been freed from the bubbles in the receiver, though it afforded an ice, that seemed to have smaller bubbles, yet this ice being thawed, part of the water was gently poured into a pipe of glass, wherein being frozen, it swelled considerably enough above its first level, and besides burst the glass, being also very opacous by reason of the bubbles.

THE third experiment was more industriously prosecuted, as may appear by this ample narrative of it, transcribed out of our Collections.

III. WE took a small egg with a pretty long neck, and pouring in water till it reached an inch within the stem, conveyed it into a long slender cylindrical receiver, provided on purpose to make trials with such tall glasses; the air being by degrees drawn out of the bubbles, appeared from time to time greater and greater, and when the receiver was well exhausted, the water seemed to boil a longer time than one would have expected; and sometimes the bubbles ascended so fast and great, that we were in doubt, whether the water did not boil over the top of the pipe. The exhausted receiver was permitted to be so for a good while, till the water had discharged it self in bubbles of its air, and then the glass-egg was removed into a vessel furnished with ice and salt, and there left ten or twelve hours, that all the water, save that in the neck, might be thoroughly frozen; and then we found it to have risen a great way above its first height: and removing it into an air tempered like that, wherein the first part of the experiment was made, and having left it there in a quiet place for ten or twelve hours to thaw leisurely, (lest too warm an air, or too much stirring the glass, might be an occasion of generating new bubbles) in the exterior part of the ice near the glass, we saw pretty store of bubbles; but when that was thawed, the rest of the ice appeared of a peculiar and unusual texture, having no determinate bubbles, that I could easily distinguish, but seeming almost like a piece of frosted glass, where the parts, that made the asperity, were exceeding thick set; but this ice swam in the water, whereinto the rest had been dissolved before it was all thawed. When there yet remained a lump about the bigness of a small walnut, we reconveyed it into the receiver, to try whether, upon the extraction of the air, the ice would be presently melted; but the alteration produced was so small, if any, that we durst not ground any thing upon it. The receiver being exhausted, there did at length appear some bubbles in the water, but they were not numerous, and a hundred of them seemed not to amount to one of those larger ones, the same water had yielded us the first time it was put in. In the ice also some small bubbles disclosed themselves, which we did not perceive there before; wherefore we took out the egg, and found (the ice being now thawed) that the water was subsided to the mark we had made, before it was exposed to congelation, if not some very little way beneath it. Then we went about to find the proportion, wherein this dispirited water was expanded by glaciation; but in pursuing this, there happened a mischance to the glass, which kept the experiment from being so accurate as we designed. And therefore, though it seemed to us, that it amounted to about the twelfth part, which is less than that of the undispirited water, yet we designed the repetition of the experiment. Only in this we could not be mistaken, that the expansion was considerable, since the water rose three inches and a half in the stem, though the whole water in the egg and stem too weighed but two ounces and a half. If the vessel had not been unluckily cracked, we should have frozen the water once more; and then sealing up the glass hermetically, and suffering the ice leisurely to thaw, should have inverted it, and broken it under water, and have proceeded with it as we had done with some other glasses in the formerly mentioned experiments.

9. [A LITTLE glass cylinder open only at one end, of a convenient length, was thrust into a deep and wide-mouthed glass, about half filled with a mixture of ice and salt: but the cylinder was neither so quite filled, that the water should run over, nor yet far short of being so; that (for all the opacous mixture of ice and salt) we might guess at the freezing of that part of the water, that we could not see by the changes appearing in the other. Then conveying all into a receiver, that we had in readiness beforehand, we quickly pumped out the air, upon which there came, both from the upper and lower parts of the water, great store of bubbles to the top, where most of them brake into a receiver. Having found, upon trials purposely made, that the engine had continued stanch all the while, and perceiving by the intumescence of the superiour parts of the water, that the other were frozen, we let in the external air, and having removed the receiver, and taken out the mixture, before the ice was half melted, we found the water, as high as the mixture reached, to be turned into ice, which, besides some large and conspicuous bubbles, had small ones enough to render it opacous; and upon the account of this expansion it was, that the water did in the free air continue a good deal higher than the mark, it was but level with, when the cylinder was exposed to freeze.]

10. THE other way we employed to examine what was contained in icy bubbles, and which seemed clearly enough to manifest, that they are very far from being filled with true and springy air, is intimated in the last clause of the foregoing narrative, but will be best understood by the annexed experiments, transcribed just as I find them registered in my collections. And though they be prolix, and contain some few particulars, that make not directly for the purpose I alledge them for, yet I think not fit to dismember or to epitomize them, or otherwise to alter any thing in them; partly, because the way of experimenting being altogether new will be best apprehended by the subjoined examples; and partly too, because those particulars, that relate not directly to the occasion of our mentioning these trials, may be useful to illustrate or confirm something, that is already delivered, or is hereafter to be delivered in the present history of cold.

11. [WE took this day a glass of the form of an egg, but of double the capacity, out of whose obtuse end rose up a cylindrical neck, capable to receive the end of my little finger, and no more; this being filled with common water, till the liquor reached a pretty way within the pipe, and the surface of the water being carefully marked on the outside, was placed in a vessel, wherein ice very grossly beaten, was mingled with a convenient proportion of salt, (according to our way of glaciation) the mixture not reaching up to the mark by above an inch. The experiment afforded us these particulars.

Feb. 4,
1661.

I. A HEEDFUL eye did not perceive the water sensibly to subside, before it began to freeze.

II. THE water began to swell, and some parts of it next the side or bottom of the glass, to freeze within a quarter of an hour.

III. THE ascent of the water in the pipe increased so fast, that within an hour, from the time the glass was put in, it did rise four inches and $\frac{2}{3}$ above the mark; and afterwards the swelling continued so, that we took it out, though a good part of the water remained unfrozen, it had reached five inches and somewhat more than a half above the first mark.

IV. THE ice and salt being purposely kept always beneath the surface of the water, the lower parts of the water were frozen, and never the upper surface.

V. DURING all this great elevation of the water, there appeared no bubbles worth taking notice of in the unfrozen parts of the liquor, but the ice was very full of

them,

them, divers of which toward the latter end of the experiment were very large bubbles, (but not all of them round) some being about the bigness of hail-shot, some small like mustard-seed, and others again not much inferior to little pease.

VI. HAVING taken out the glass, when the water was at the highest mark, we did, upon a certain design, pour in as much sallet-oil as swam about two inches above it, and then the glass was nimbly at the flame of a lamp sealed up, during which time the included water subsided a little; but the glass being again put into the ice and salt, the cold quickly restored the water to its former height, and there remained about an inch and half of the sealed glass unpossessed by the two contained liquors.

VII. THEN with a good pair of scales we weighed the glass-egg first in the air, and then in the water, (the better to discern, whether any shrinking of the glass intervened in the case) where it hung freely, and was left hanging in its æquilibrium with its opposite weight.

VIII. WHILST it thus hung, upon the thawing of the ice many bubbles great and small ascended (the great ones with a wriggling motion) and vanished at the top.

IX. As the ice thawed, the water and oil descended, till the whole ice was returned to water; at which time we observed these two remarkable things; the one, that the æquilibrium remained the same; the other, (which was more considerable) that the water was subsided again as low as the first mark, with which it was level before it began to swell, without falling beneath it, notwithstanding the recess of such a multitude of bubbles, divers of which were very large.

X. THE glass being inverted, the sealed end, which was drawn slender, was gently broken under water, of which some, being impelled in, did sensibly reduce the air at the opposite end into a narrower room; and, as one of the spectators observed, into a much narrower, which is consonant enough to reason.

XI. THE glass being again inverted, and held till it was settled, we found, that the water drawn in together with the water it found there, and the oil, possessed the same places, (as appeared by the marks in the cavity of the receiver) that they did, when it was sealed up.

XII. AND lastly, having thrown out the oil, and employing, where need was, a little water of the same kind we had made use of all this while, we found the glass filled to the highest mark, to weigh 4374 grains; when it was filled but to the lowest mark, 4152 grains; and when quite emptied, 1032. So that the water contained betwixt the highest and lowest mark, and raised by the glaciation, was about a fifteenth part of the water set to freeze; and probably would have amounted to much more, if the water had been all frozen.

Dec. 17,
1662.

12. [A LARGE glass-egg being taken with a proportionably big stem, we poured water into it, till it reached about an inch above the bottom of the stem, and fastening a mark there, we exposed it all night to freeze in snow and salt; which was so placed, as not to reach so high as the bottom of the stem. The next day about ten of the clock we found the water risen in the stem about 15 inches above the mark, the whole cylinder of water being fluid by reason of the snow's not reaching to it. (Then upon a design, to be elsewhere mentioned, we sealed up the glass by a very slender pipe, that had been before purposely drawn out to a pretty distance from the body of the cylinder, that the glass might be sealed in a trice, before the flame of a candle could sensibly rarify the air, and after a while we broke off the apex of this slender pipe in prosecution of our former design.) Then suffering the water to swell freely, within seven or eight hours it reached the very top of the glass, a drop or two running over at the slender orifice thereof; so that in all, the water ascended about 19 inches above the first mark. Then we tried by the flame of a candle to seal the glass, but by reason of the rarification

rarification of some of the water, by the heat, into vapours, by which some of the other water was, from time to time, spurted against the flame of the candle, we found it troublesome enough to seal it up, the vessel being removed into a warm place, till next morning; and all the ice in the belly of it (for the water in the stem continued fluid) being thawed, the water subsided, not only to its first mark, but a little beneath it, by reason of that which was thrown out, upon occasion of the sealing of the glass. But when we came to invert this, after the manner above mentioned, into a vessel of water, to see how much of the space deserted by the thawed ice was filled with air, and how much was filled with a subtiler substance, or empty, just then a mischance frustrated our expectation.]

13. [AN egg about the same bigness with the former was placed to freeze in beaten ice and salt, and in less than an hour, it was risen near an inch above the mark, where the surface of the water was at the first, and the water in the ball and the joining of the neck was frozen into *laminæ*. After an hour and a quarter, those *laminæ*, that before appeared in the beginning of the neck, now disappeared; but the ball seemed frozen into a white ice, and the water in the neck was risen above the first mark four inches and a half. There now appeared abundance of small bubbles, continually ascending through the neck, (which so continued all the time after, till it was quite thawed) and the white ice appeared full of bubbles. The experiment being further pursued, the water ascended higher and higher, till it had reached about eight inches above the first mark: then the top of the pipe being with a lamp drawn out into a very slender cylinder (for the conveniency of sealing up) the glass was again put into the ice, that the air heated by the lamp might cool; upon which the water continued swelling, till it began to run over at the orifice of the slender pipe, which being held by, in the flame of a candle, was in a trice sealed up; so that the whole glass appeared full of water, bating an inconsiderable quantity of rarified air, (not amounting to the bigness of half a small pea) that remained contiguous to the sealed part. The egg being brought into a warm room, was kept there all night, and a good part of the next morning, before the ice was quite thawed; which when it was, the water was found subsided to the first mark, and which being done, the glass was inverted, and the sealed end immersed a good way under water; where being broken, the external air impelled the water in the basin into the cavity of the pipe, insomuch, that when we took it out, which we did, as soon as we thought no more water was impelled up, reinverting the glass, we found, that the admitted water reached seven inches above the first mark, and left an inch and an half of the stem, before it began to be withdrawn, besides as much of the slender part of the stem, as by guess amounted to a quarter of an inch more: so that it seemed, that the bubbles, which made the water swell, and appeared in the ice, amounted to an inch and three quarters of air, which consequently seemed to be for the most part generated by this operation, and to seven inches either of a vacuum, or some subtiler substance, which by its having no spring to resist the pressure of the outward air, appeared not to be air. We could not exactly measure the quantity of water we had in all, and the proportion of it betwixt the marks, because having left the glass in the window, to try whether time or cold would make the admitted water shrink, (which we did not find it to do) the weather was too sharp, that beginning (as we concluded) to freeze the water in the stem, the increasing ice burst out the belly of the glass into many pieces.]

Another time.

14. [A sealed glass being broken under water, there was impelled into the cylinder ten inches and a little above a half. And the mark it should have risen to, was eleven inches and a quarter above the first and lowest mark.]

Another time.

Decemb.

15. [In the same bolt-head, wherein the greatest condensation of the air was tried, the water was by the cold made to swell very near a foot above the mark it rested at, when it began to freeze; then the glass being nip'd up, the contained water was removed, and suffered leisurely to thaw, and upon the dissolution of the ice, the water fell back to the former mark. Lastly, the glass being inverted, the apex was broken off under water, and the water in the stem was, by the outward air pressing upon the water in the basin, with some impetus and noise driven up into the cavity of the glass; and, the glass being seasonably and warily removed from the basin, we found there had been impelled up of the water in the basin, a little more than eleven inches; so that there seemed to be near $\frac{1}{2}$ of an inch of air generated or separated by the former operation.]

*Another time.*Decemb.
17.

16. IN the same glass we made the water to swell about ten inches, and inverting the stem, and breaking the neb under water, we found about ten inches of water to have been impelled into the stem; so that in this there seemed no generation of air.]

17. To all these experiments we shall subjoin, in two words, that as in water, so in some aqueous liquors we found, that the icy bubbles were not filled with air (though we did not think fit to take the pains to measure their respective expansions by being congealed:) for in that elsewhere mentioned experiment, where we exposed milk, urine, and Rhenish-wine to freeze, when all those liquors were risen above their former marks, as is there related, our notes inform us, that the experiment was thus prosecuted.

18. [BEING sealed up (the foregoing words mentioned the above-named expanded liquors) and suffered to thaw, the several liquors subsided to their first marks or thereabouts, and the glasses being inverted and broken under water, we were, by an accident, hindered from observing what we desired in that, which had the wine, though when it was taken out of the freezing pot, it had ice, but not much, swimming in it. But into the glass, that had the milk, the water was manifestly impelled by the outward air; and so it was into the glass, that had the urine, which being removed from the basin, and reinverted, appeared to have as much new liquor in its stem, as amounted by guess to five or six inches.]

19. To which experiment we may add, that another time a sealed glass of partly frozen claret-wine being broken under water, the water was impelled up between half an inch and an inch above the mark, beyond which it would not have ascended, if the bubbles had been full of true and permanent air.

20. If it be said, that though I have delivered too many particulars about so empty and slight a theme as bubbles, I have this to answer, that possibly all these experiments have rather shewed us, what it is not, that fills them, than what it is; so that more than all these experiments appearing requisite to clear up the difficulties about them, I shall not think I have altogether mis-spent my time, especially if so many past experiments, both new, and not altogether impertinent, by their not having taught us enough about so despicable a subject as a bubble, shall, as they justly may, teach us humility.

TITLE X.

Experiments about the measure of the expansion and the contraction of liquors by cold.

1. **T**O the experiments (mentioned in the seventh and ninth titles) which shew, that water has an expansion, it will be proper to subjoin some of those whereby we endeavoured to measure that expansion. And here we shall not content ourselves to say, that whereas the authors we had formerly occasion to point at, take notice of their having raised water in a bolt-head half an inch or an inch by freezing, we have made it ascend a foot and a half and more; this, I say, we shall pass by, because that though by such experiments we have very clearly and undeniably manifested the expansion of the water, yet unless the capacity of the vessel be known, they will signify but little towards the determining the quantity of that expansion, which yet is the thing we are enquiring after: wherefore we shall add, that we employed two differing ways to measure this expansion.

2. **T**HE one was, by putting in, by weight, such a number of ounces of water into a bolt-head, till the water was risen a pretty way in the long stem wherewith it was filled; then marking on the outside, to what height every freshly added ounce of water reached in the stem, we afterwards poured out a convenient quantity of the liquor, (yet leaving enough to fill the whole cavity of the spherical or obtuse end of the vessel, and of the lower part of the stem) then leisurely freezing this remaining water from the bottom upwards, we observed, that when it was frozen, the ice, that was made of 82 parts of water, filled, as one of our notes inform us, the space of 91, and (if I mistake not the character) an eighth; so that by this troublesome way of examination, we found, that the water, by the expansion it received from cold, was made to possess about a ninth part more space than it did before congelation.

[3. **I**N another of our notes, we find as follows, 55 parts of water extended themselves by freezing into 60 and $\frac{1}{2}$, about 6 of those parts remaining unfrozen; so that in this experiment the water's expansion was not much (though somewhat) differing from what it was in that last mentioned.]

4. **T**HE other way we made use of to measure the dimensions, that water gains by freezing, was to take a cylindrical pipe of glass, sealed at one end, and left open at the other; at which we filled it with water to a certain height, that we took notice of, by a mark applied to the outside, and then keeping it in an erected posture, and freezing it from the bottom upwards, we found, that it had acquired by a tenth part, or thereabouts, greater dimensions in the form of ice, than it possessed in the form of water. But the nature of the particular parcel of liquor exposed to the cold, (for it is not necessary, that all waters should be equally disposed to be expanded by freezing) and some other circumstances, not now to be discoursed of, may well beget some little variety in the success of this sort of trials. For in one, that we made carefully, we found the expansion somewhat greater, than that last mentioned, as may appear by the following note; which, compared with what was lately delivered, of the trials we made by weight of the water's expansion, may invite us to think, that we cannot much err by estimating in general, that the room, that ice takes up more than water, amounts to about a ninth part of the space possessed by the same water, before it was turned into ice. The note we were speaking of, is this:

[5. **I**N

[5. In a more than ordinarily even cylindrical glass, we exposed some water to freeze, to measure its intumescence, and found, that it expanded itself to about an eighth part, or at least a ninth upon glaciation; this we tried twice, and thought, that the intumescence might have been more considerable, but that in a cylinder the freezing did not seem to succeed so well.]

BUT here we must resolve a difficulty, which, though ordinary readers may take no notice of, yet may breed a scruple in the minds of those, that are acquainted with hydrostatics. For to such readers this account of ours may seem to be contrary to the experience of navigators into cold climates, who tell us (as we shall have occasion to take notice of in due place) of vast pieces of ice, as high, not only as the poops of their ships, but as the masts of them; and yet the depth of these stupendous pieces of ice seems not at all answerable to what it may be supposed to be, in case we compare together the estimate above delivered of the expansion of water, and that grand hydrostatical theorem demonstrated by *Archimedes* and *Stevinus*, 'That floating bodies will so far, and but so far, sink in the liquor, that supports them, till the immersed part of the body be equal to a bulk of water, weighing as much as the whole body.' For Captain *James*, in his often-cited voyage, makes mention of great pieces of ice, that were twice as high as the top-mast-head of his ship.

6. AND the *Hollanders*, in their famous voyage to *Nova Zembla*, mention one stupendous hill of ice; which I therefore take notice of here, not only because it has been thought the greatest, that men have met with, but because they deliver its dimensions, not as Captain *James* and navigators are wont to do, by comparison with the unknown heights of some of the masts of their ships, but by certain and determinate measures, which, in the icy island we are speaking of, were so divided by the surface of the water, that there was 16 fathom extant above it, though there were but 36 beneath it: which, though a vast depth in itself, yet does but little exceed double the height.

Barthol.
de nivis
usu, Cap. 6.

AND the Danish navigator *Janus Munckins*, employed by his king to bring him an account of *Greenland*, mentions some floating pieces of ice, that he met with and observed in that sea, which, though but somewhat above 40 fathom under water, were extant 20 fathom (that is, near half as much) above water; whereas it seems, that, according to our above-mentioned computation of the expansion of water, the part under the water ought to be eight or nine times as deep as that above the water is high.

7. To clear this difficulty, I shall represent these three particulars:

FIRST, that in our computation, the ice, that sinks so deep, is supposed to float in fresh water; whereas, in the observations of the above-named navigators, those vast pieces of ice floated on the sea-water, which by reason of its saltness, being heavier than fresh water, ice will not sink so deep into that, as into this. And that salt may hugely increase the weight of the water, wherein it is dissolved, may be clearly gathered from the ponderousness of common brine, and from the practice of several sorts of tradesmen, who, to examine the strength of their lixiviums, and other saline liquors, are wont to try, whether they will keep an egg floating, which we know common water will not do. And I have also, by the resolution of some metalline bodies in fit menstruums, made liquors, that are yet much more ponderous, than is sufficient for the support of eggs.

BUT yet we must be so candid, as to take notice of what some modern geographers deliver with probability enough; namely, that nearer the poles the seas are not wont to be so salt, as in the temperate and the torrid zones: and those northern being

being not so salt as our seas, there is the less to be allowed for the difference in gravity (and consequently in the power to keep ice from sinking) betwixt those seas and ours.

8. But secondly, this lesser saltness of the water in the northern seas may, as to our case, be recompensed by the greater coldness of it. For though, as we have formerly observed, the condensation of fresh water, effected here by a degree of cold capable to make it begin to freeze, is not so great as most men would imagine; yet besides that I have often taken pleasure to make the same body to sink or ascend in the same water, by a much less variation of cold than that we have been mentioning; it is to be considered, that the degree of cold, to which water was brought in the experiment delivered in the fourth section, to which we are now looking back, was but such a degree, as would make fresh water begin to freeze: whereas the salt sea-water, being indisposed to congelation, may, by so vehement a cold as reigns in the winter-season in those gelid climates, be far more intensely refrigerated, and thereby more condensed than common water is here, by such a measure of cold, as may begin to freeze small portions of it. But though what we have hitherto represented, may well be looked upon as not inconsiderable to the purpose, for which it has been alledged, yet the main thing, that is to remove the scruple suggested by the height of icy hills above the water, is,

9. THIRDLY, that such hills of ice are not to be looked upon as intire and solid ones, but as vast piles or lumps, and masses of ice, casually and rudely heaped up and cemented by the excessive cold, freezing them together by the intervention of the water, that washes them; which piles of many pieces of ice are not made without great cavities intercepted, and filled only with air, between the more solid cakes or lumps: so that the weight of these stupendous pieces of ice is not to be estimated by the bigness they appear of at a distance from the eye, but considering how much air there is intercepted between the icy bodies, of which they are compiled, there may be a hollow structure of ice reaching high into the air, and yet the whole aggregate or icy pile, will press the subjacent water on which it leans, no more than would as much water, as were equal in bulk only to the immersed parts; as we see in barges loaden with boards, which, though piled up to a great height above the water, make not the vessel to sink more than a lading, that would make a far less shew, and oftentimes be all contained within the cavity of the vessel, provided it be more ponderous *in specie*. But to enter into any further consideration of these hydrostatical matters, would be improper in this place, especially since we have * elsewhere treated of them. And that these floating hills and islands of ice are not intire and solid pieces of it, we shall elsewhere have occasion to shew out of navigators, and even in the observation we have mentioned out of *Janus Munck*, the learned relator of it. *Bartholinus* takes notice, that those vast pieces of ice (we have been mentioning) that reached 20 fathom above water, were compiled of store of snow frozen together.

10. THESE considerations may serve to render some account of those stupendously tall pieces of ice, whose extant parts bear so great a proportion to the immersed part, when the whole mass does really float. But I confess I doubt, that not only in the examples we have alledged, but in other eminent ones of mountains of ice, if I may so call them, there may be a mistake; and that the height of them above the water would be far less, and the depth under water far greater, if the ice had water enough to swim freely. For seamen, by reason of the difficulty, are not wont to measure the height of those pieces, that float at liberty in the sea. And as for those, that are on ground, as their heights lie far more convenient to be measured, so the measurers not

* In our
Hydrostatical
Paradoxes.

Ex nive
copiosa
glaciata
compacta.

knowing how long they have been on ground, for aught I know, much of that admired height may be attributed to the snows, that from time to time fall very plentifully in those frozen regions, and are compacted together, either by the sun, whose beams sometimes begin to thaw it, and sometimes by the water of the waves that beat against the ice, and being congealed with the snow, does as it were cement the parts of it together, and sometimes by both of these causes. So in the instance alledged out of Captain *James*, page 14. of pieces of ice, that were twice as high as his topmast-head; it is said also, that they were on ground in 40 fathom. And in the other example mentioned out of *Baribolinus*, though there be 40 fathom attributed to the immersed part of the ice, yet that measure is not exclusive of a greater; for it is said, that the ice reached downwards above 40 fathom; and how much downwards, and whether as far as the ground, we are left at liberty to guess. And in that stupendous piece of ice recorded in the *Nova Zembla* voyage, to have been in all 52 fathom, that is 300 and twelve foot deep, though it be granted what they affirm, that it was 16 fathom above the water, which is almost a third part of the whole depth; yet I observe, that of this icy mountain it is said, that *it lay fast on the ground*. So that as on the one side it seems probable, that the upper part of islands of ice may be increased by snow; and, as I remember, that in that famously inquisitive navigator Mr. *Hudson's* voyage for the discovery of the North-west passage, it is related, that his company was * 'so well acquainted with the ice, that when night, or foggy or 'foul weather took them, they would seek out the broadest islands of ice, and there 'come to anchor, and run and sport, and fill water that stood on the ice in ponds 'very fresh and good.' So on the other side we know not, how much lower the Dutchmen's ice and Captain *James's* would have reached into the sea, in case the ground they rested on, had not hindered them. For though one might probably think, that these are the greatest depths, that any hills of ice have been observed to attain, (that mentioned by the *Hollanders* reaching 36 fathom beneath the water, and that mentioned by Captain *James*, no less than 40 fathom) yet I find in Mr. *Hudson's* voyage, that the English, in the bay that bears his name, met with more than one or two islands of ice, of a far greater depth under water. For among other things, the relator has this memorable passage; 'In this bay, where we were thus troubled 'with ice, we saw many of those mountains of ice aground, in six or seven 'score fathom water.' And if the sea had been deep enough, even these stupendous moles of ice would probably have sunk much lower, and so have lessened the heights of the mountains.

11. I KNOW, that delivering the measure of the expansion of water alone I have not said all, that may be said about the expansion of liquors; but because, as it has not yet appeared to me, that any liquor is expanded by cold, unless by actual freezing; I doubted, whether aqueous liquors, as wine, milk, urine, &c. were otherwise expanded by congelation, than upon the account of the water or phlegmatick (and, in a strict sense, congealable) part contained in them; and whether it were worth while, for a man in haste, to examine their particular expansions. Notwithstanding which, I would not discourage any from trying, whether or no, by the differing dilations of aqueous liquors, some of them of the same, and some of them of differing kinds, we may be assisted to make any estimate of the differing proportions they contain, of phlegm, and of more spirituous or useful ingredients.

* Mr. *Hudson's* voyage for the discovery of the North-west passage, written partly by Mr. Abacuck Pricket.

12. AFTER what has been hitherto delivered concerning the expansion of liquors by cold, it may be expected we should say something of the measure of their contraction by the same quality. But as for water, which is the principal liquor whose dimensions are to be considered, I have formerly declared, that I could seldom or never find its contraction (in the winter season when I tried it) to be at all considerable. And I shall now add, that having, for greater certainty, procured the experiment to be made by another also, in a bolt-head, the account I received of it was, that he could scarce discern the water in the stem to fall beneath its station, (marked at the upper part of the pipe) when the water in the ball was so far in frigidated as to begin to freeze. Though I will not deny, that in warmer climates, as *Italy* or *Spain*, the contraction of the water, a little before glaciation begins, may be somewhat considerable, especially if the experiment be made in summer, or in case (either there or here) the water exposed to freeze be put into a vessel very advantageously shaped, or brought out of some warm chamber or other place, where the heat of the air, that surrounded it, had rarified it. But to examine the measures of contraction in the several liquors, and with the nice observations, that such a work, to be accurately prosecuted, would require, would have taken up much more of my time than I was willing to employ about a work, which I looked not on as important enough to deserve it. And therefore I shall here add nothing to what I have said under the title of the *Degrees of Cold*, touching the contraction of spirit of wine and oil of turpentine, by the differing degrees of that quality; and as for the condensation of air, the vastest fluid we deal with, I did indeed think fit to measure how much cold condenses it. But the account of that experiment will be more opportunely delivered in * one of the following discourses.

* In the
sect. about
the tempe-
rature of
the air.

T I T L E X I.

Experiments touching the expansive force of freezing water.

1. **H**AVING shewn, that there is an expansion made of water, and aqueous bodies, by congelation, let us now examine how strong this expansion is, and the rather because no body has yet, that we know of, made any particular trials on purpose to make discoveries in this matter: so that although some unhappy accidents have kept our experiments from being as accurate as we designed, (and as, God assisting, we may hereafter make them) yet at least we shall shew this expansion to be more forcible, than has hitherto been commonly taken notice of, and assist men to make a somewhat less uncertain estimate of the force of it, than they seem to have yet endeavoured to enable themselves to make.

2. AND (1.) we shall mention some experiments, that do in general shew, that the expansion of freezing water is considerably strong.

WE took a new pewter bottle, capable to contain, as we guessed, about half a pint of water, and having filled it top full with that liquor, we screwed on the stopple, and exposed it during a very frosty night, to the cold air; and the next morning the water appeared to have burst the bottle, though its matter were metalline, and though purposely for this trial we had chosen it quite new, the crack appeared to be in the very substance of the pewter. This experiment we repeated; and it was one of those bottles filled with ice, that had cracked it, which a noble virtuoso would need make me (who should else have scrupled to amuse, with such a trifle, so great a monarch, and so great a virtuoso) bring to his Majesty, to satisfy

him, by the wideness of the crack, and the protuberance of the ice, that shewed it self in it, that the water had been really expanded by congelation.

3. WE also tried, whether or no a much smaller quantity of water would not, if frozen, have the like effect; and accordingly, filling with about an ounce of water a skrewed pewter box (such as many use to keep treacle and salves in) quite new, and of a considerable thickness, we found, that upon the freezing of the included water, the vessel was very much burst.

AFTERWARDS filling a quart bottle (if I mistake not the capacity) with a congelable liquor, and tying down the cork very hard with strong packthread, we found, that the frost made the liquor force out the stopple, in spite of all the care we had taken to keep it down.

BUT afterwards we so well fastened a cork to the neck of a quart bottle of glass, that it was easier for the congealed liquor to break the vessel, than to thrust out the stopple; and having for a great many hours exposed this to an exceeding sharp air, we found at length the bottle burst, although it were so thick and strong, that we were invited to measure the breadth of the sides, and found that the thinnest place, where it was broken by the ice, was $\frac{3}{8}$ of an inch, and the thickest $\frac{3}{4}$, that is, twice as much: we also by the help of the frost broke an earthen bottle of strong *Flanders* metal, of which the thinnest part, that was broken, was equal, by measure, to the thinnest part of the other.

4. BUT the above mentioned instances serving only to declare in general, that the expansion of water by cold is very forcible, I thought fit to attempt the reducing of the matter somewhat nearer an estimate less remote from being determinate; and because the water exposed to congelation may be probably supposed to be homogeneous, we judged, that the quantity of it, may very much vary its degree of force; and because some may suspect, that the figure also may not be inconsiderable in this matter, we thought fit to make our trials in a brass vessel, whose cavity was cylindrical, and which, to make it stronger, had an orifice but at one of its ends; and whose thickness was such, that we had reason to expect, that whilst the top remained covered, but with a reasonable weight, the included water would find it more easy to lift up that weight, than break the sides. To this cylinder we fitted a cover of the same metal that was flat, and went a little way into the cavity, leaning also upon the edges of the sides for the more close stopping of the orifice: the cavity of this cylinder was in length about five inches, and in breadth about an inch and three quarters. This cylinder being filled top-full with water, and the cover being carefully put on, was fastened into an iron frame, that held it erected, and allowed us to place an iron weight, amounting to 56 pound, or half a hundred of common English weight; which circumstance I mention (because the common hundred, that our carriers, &c. use, exceeds five score by twelve.) But this vessel being exposed in a frosty night to the cold air, the contained water did not the next morning appear to be frozen, and the trial was another time that way repeated with no better success, as if either the thickness or clearness of the metal had broken the violence of the external air's frigeactive power, or the weight, that oppressed the cover, had hindered that expansion of the water, which is wont to accompany its glaciation.

WHEREFORE we thought it requisite to apply to the outside of the vessel a mixture of salt, with ice or snow, as that, which we had observed to introduce a higher degree of cold than the air alone, even in very frosty nights; and though this way it self, the glaciation proceeded very slowly, and sometimes scarce at all, yet at length we found, that the water was by this means brought so far to freeze, that on the morrow ice had

had on one side swelled above the top of the cylinder, and by lifting the cover on that side, had thrown down the incumbent weight; but in this trial the cover having been uniformly, or every where lifted up above the upper orifice of the cylinder, we repeated the experiment divers times, as we could get opportunity, sometimes with success, and sometimes without it; and of one of the chief of our experiments of this sort, we find the following account among our collections.

5. [THE hollow brass weight, being about one inch and three quarters in diameter, and the brass cover put on, was loaded with a weight of 56 pound upon the cover and exposed to an excessively sharp night: the next morning the cover and the weight were found visibly lifted up, though not above (that we could discern) a small barley-corn's breadth, but the thickness of the brass cover was not here estimated, which was much less than half an inch, which, according to former observations, one might expect to see the ice ascend. But that, which we took particular notice of, was, that the inclosed cylinder of ice, being by a gentle thaw of the superficial parts taken out, appeared so full of bubbles, as to be thereby made opacous. Also when in the morning the cylinder was brought into my chamber, before the fire was made, the 56 pound weight being newly taken off, at a little hole, that seemed to be between the edge of the brass and ice, there came out a great many drops of water, dilated into numerous bubbles, and reduced in a kind of froth, as if upon the removal of the oppressing weight the bubbles of the water had got liberty to expand themselves; but this lasted but a little while.]

6. AFTER this the difficulty we have often met with in the placing of great weights conveniently upon the cover of a cylinder, and the expectation we had to find the quantity of the water we made use of, capable, upon its congelation, to lift up a much greater weight, invited us to make trial of its expansive force, by somewhat a differing way; which was, to fit a wooden plug to the cavity of the cylinder, (after we had suffered it to soak a convenient time in water, that, swelling as much as it would before, it might be made to swell no more by the water, which would lie contiguous to it in the vessel) and then to drive it forcibly in, till by considerable weights appended to the extant part of the plug, when the cylinder was inverted, we could not draw it out. The success of one of these trials is thus set down in our collections:

7. [A PLUG was driven into the cavity of a brass cylinder, first filled with water, the plug being also well soaked; then the cylinder being inverted, the plug took up half a hundred and a quarter of a hundred weight, and would possibly have taken up much more, and being exposed to a very sharp night, the freezing water thrust out the plug about a barley-corn's breadth, quite round above the upper edge of the cylinder; and it freezing all that day and the next night, it was again exposed, the plug not being yet taken out, and then the plug was beaten out a little more, namely, (in all) near a quarter of an inch.]

8. THUS we see, that the expansive endeavour of the water forced a resistance, at least equal to that, which would have been made by a weight of 74 pound; and probably, as the note intimates, would have appeared able to do more, if we had had convenient weights and instruments, wherewith to have measured the strength of the water's endeavour outwards, which some subsequent trials made us think very considerable; though not finding their events set down in our notes, we think it fit at present to leave them unmentioned.

BUT one thing there is in these trials, that I think not unworthy a philosopher's notice, and his considering; namely, that this endeavour of the water to expand itself is thus vigorous, though the uttermost term, to which it would expand itself, in case

case it were not at all resisted, would be but to about a ninth, or at most an eighth part of the space it possessed before it began to freeze; whereas air may by heat (which yet, we have * elsewhere shewn, will not reduce it to any thing near its utmost expansion) be brought to possess (though not to fill) according to the diligent † *Mersennus's* observation, seventy times the dimensions it had before rarification; and consequently the air expanded by heat does by its endeavours tend to acquire above 60 times the space, that the water does, when expanded by so high a degree of cold, as is capable to turn it all into ice: not to mention, that the expansion, to which the air tends upon the account of its own spring, is (as we shew in another ‡ place) many times greater than that, to which *Mersennus* could bring it upon the bare account of heat.

9. THERE remains yet one way, whereby we hoped, though not to measure the expansive force of freezing water, yet to manifest it to be prodigiously great; or in case we failed of this aim, to produce at least some other phænomena relating to cold, that would not be inconsiderable. And though our endeavours succeeded not, yet because a happier opportunity may bring them to be one way or other successful, we shall annex, that we caused to be made an iron ball of between two and three inches diameter; which ball was solid, save that in the midst there was a small cavity left to place a little water in, together with a female screw, as they call it, reaching from the outward surface of that internal cavity; and to this was applied a strong iron screw, so fitted to the internal cavity of the other screw, as to fill it with as much exactness as could be obtained. And this screw was made to go so hard, that it required to be screwed in by the help of a vice, that it might not be forced out, without breaking the iron it self. Our design in employing this instrument was, that having well filled the internal cavity with water, and forced in the screw as far as it could be made to go, the instrument thus charged with water might be exposed to the highest degree of cold we could produce. For having thus ordered the matter, we thought we might expect, either that the water, how much soever we heightened and lengthened the cold, would not freeze at all, being hindered from the expansion belonging to ice in comparison of water; or, if it did freeze, that one of these two things would happen, either that the expansive force of that little water would, by forcing such an iron instrument, manifest its strength to be stupendous; or, by not breaking it, present us with ice without bubbles, or at least not rarer and lighter, than the water it was made of: but for want of a sufficient cold, our designs succeeded not, so as to satisfy us, though we more than once attempted it. For the great thickness of the iron being considered, we were not sure, that the waters not freezing might not proceed rather from the thickness and compactness of the metal, than from its resistance to the expansion of water. And therefore we must suspend the inferences, this experiment may afford us, till we have opportunity to make trial of it, with a cold not only very intense, but durable enough; the want of which last circumstance keeps us from daring to build any thing on our experiment.

10. AND here we may take notice, that it may be an inquiry, more worthy a philosopher, than easy for him, whence this prodigious force, we have observed in water, expanded by glaciation, should proceed. For if cold be but, as the Cartesians would have, a privation of heat, though by the recess of that ethereal substance, which agitated the little eel-like particles of the water, and thereby made them compose a fluid body; it may easily enough be conceived, that they should remain rigid in the postures, wherein the ethereal substance quitted them, and thereby compose an

* New Experiments Physico-mech. Exper. 6.
 † See the fore-cited place.

‡ The Appen-

unfluid

unfluid body like ice: yet how these little eels should by that recess acquire as strong an endeavour outwards, as if they were so many little springs, and expand themselves too with so stupendous a force, is that, which does not so readily appear. And on the other side, in the Epicurean way of explicating cold, though the phenomenon seems somewhat less difficult, yet it is not at all easy to be solved: for though, granting the ingress of swarms of cold corpuscles, the body of water may be supposed to be thereby much swelled and expanded, yet besides that these corpuscles, stealing insensibly into the liquors they insinuate themselves into, without any shew of boisterousness or violence, it is not so easy to conceive, how they should display so strange a force against the sides of those strong vessels, that they break, when they may as freely permeate or enter them: besides this, I say, we observe, that in oil, which requires a far greater degree of cold to be congealed to a good degree of hardness, the swarms of frigorifick atoms, that invade it, are so far from making it take up more room than before, that they reduce it into less, as may appear by those former experiments, which manifested, that cold does not expand, either oil or uncongealable liquors, but condense them.

11. AFTER what I have thus largely delivered, concerning the expansive endeavour of freezing water, I hope I may be allowed to leave to others (if they shall think it worth the labour) the prosecution of the like experiments upon wine, milk, urine, and other liquors abounding with aqueous parts; concerning which, we shall only in general remind those, that may have forgotten it, that by some of our experiments it appears, that such aqueous liquors are expanded by congelation, and that their endeavour outward is considerably forcible, seems more than likely from what we formerly noted out of the Dutch voyage to *Nova Zembla*, where it is related, that by the extreme cold, both some of their other barrels, and some of those that were hooped with iron, were, as they speak, frozen in pieces; that is, according to our conjecture, burst together with the hoops, whether of wood or iron, by the expansive force of the imprisoned liquors brought to freeze.

12. To which I shall add, that when I asked an ingenious person, whether in *Russia*, where he lived a good while, beer and wine did not, when brought to congelation, break the vessels they were frozen in; he answered, that he had not observed wooden vessels to have been broken by them, (perhaps because of their yielding) but glass and stone bottles often.

T I T L E XII.

Experiments touching a new way of estimating the expansive force of congelation, and of highly compressing air without engines.

1. **T**HERE is yet another way, that I bethought my self of, at once to measure the force, wherewith freezing water expands it self, and to reduce the air to a greater degree of condensation, than I have as yet found it brought to by any unquestionable way of compressing it. But whereas by this method, to determine exactly the expansive force of the water, it were requisite not only to know the quantity of the water, and that of the air exposed to the cold, but to make the experiment in vessels conveniently shaped to measure the dilatation of the one, and the compression of the other; our experiments being made in a place, where we were not provided of such glasses, we were not able to make our trials so instructive and satisfactory, as else we might have done. Nevertheless, we shall not scruple to subjoin those of them, that we find noted down among our collections, allowing our selves to hope, that they will not be unacceptable or appear impertinent, not only upon the account of their novelty, but for two other reasons,

2. **T**HE

2. THE first, because though they do not accurately define the expansive force of freezing water, yet they manifest, that it is wonderfully great, better perhaps than any experiment, that has been hitherto practised, (not, to say, thought of) as may appear by comparing what we have delivered in another treatise, of the great force requisite to compress air considerably, with the great compression of air, that has already been this way effected.

3. THE second, because this new way affords us one of condensing the air much farther than hitherto it has, by any method I have heard of, been unquestionably reduced; I say, unquestionably, because though the diligent *Mersennus*, and others, seem to have conceived himself to have reduced it in the wind-gun into a very narrow room; yet besides that, by our expedient, we have compressed it beyond what these ingenious men pretend to; besides this, I say, I have long much questioned, whether the way of compressing air in a wind-gun, which both they and we have employed, may safely be relied on. For the oil or some other analogous thing, that is wont this way to be employed, and the overlooking of several circumstances, that are more necessary to be taken into diligent consideration, than wont to be so, may easily enough occasion no small mistake in assigning so great a degree to the compression of the air; but our exceptions against this way of measuring it may be more opportunely discoursed of in another place. And therefore we will now proceed to take notice, that of the two known ways of compressing air, the clearest and most satisfactory seems to be that, which is performed in the wind-fountain, as it is commonly called, where yet I have seldom, if ever, seen the air, (that I remember) by all the violence men could use to syringe in water, crouded into so little as the third part of the capacity of the vessel. And an ingenious artificer, that makes store of these fountains, being consulted by me, about the further compressing of air in them, he deterred me from venturing to try it, by affirming to me, that both he and another skilful person of my acquaintance had like to have been spoiled by such attempts: for endeavouring to urge the air beyond a moderate degree of compression, it not only burst some fountains made of glass, but when the attempt was made in a large, but thick vessel, made of strong and compact *Flanders* earth (the same with that of jugs and stone bottles) the vessel was, by the over-bent spring of the air, burst with a horrid noise, and the pieces thrown off with that violence, that if they had hit him, or his friend, that assisted him in the experiment, they might have maimed him, if not killed him out-right. So that the greatest unquestionable compression of the air seems to have been that, recorded in the fifth chapter of our defence against the learned *Linus*, where, nevertheless, we could reduce the air by the weight of a cylinder of mercury of about 100 inches, (which consequently might near countervail a cylinder of sixscore foot of water) but into a little less than a fourth part of its usual extent; but how much further the air may be compressed by our new purposed way, it is now time to shew by the ensuing notes, of which we have not omitted any, that we could find, both that some scruples, which might else arise about the way we employed, may be prevented or satisfied; and that the way, we employed in practising this method, might by some variety of examples be the better understood.

[4. WE took a large glass-egg, with a cylindrical stem about the bigness of my little finger, and pouring in water, till it reached about a finger's breadth higher than the bottom of the stem, we set it to freeze in snow and salt, for some hours, with the top of the stem (which was drawn out into a very slender pipe, almost at right angles with the stem) open, and there left it for some hours, and the water was risen betwixt six and a half, and seven inches. This we did in order to another experiment; but then easily and nimbly sealing up the slender pipe above-mentioned, that the air in the

stem

stem might not be heated, we let it continue in the snow some time, adding fresh for about 24 hours, to observe to what degree the water, by expanding itself, would compress the imprisoned air. The length of the cylinder of the air to be condensed at the time of the sealing, was (accounting by estimation for the slender pipe newly taken notice of) almost $9\frac{1}{2}$ inches. This space we observed the ascending water, as the ice increased below, to invade by degrees; (for we watched it, and measured it from time to time) so much, till at length the water reached to 8 inches and $\frac{7}{8}$ almost, above the station (which we had carefully marked with a diamond) in which we found it, when the glass was sealed up, leaving but about an inch of air at the top; so that of the whole space before possessed by the air, the water had intruded into near nine parts of ten. Then being partly apprehensive the glass would hold no longer, but have its upper part blown off, as it happened to us a little before with another vessel, and partly being desirous to try that which follows, we leisurely inverted the glass, that the air might get up to the ice; for all the water in the stem had been purposely kept unfrozen: and having provided a jar to receive the water, that should be thrown out, we broke the slender pipe, which we had sealed up, and immediately, as we expected, the compressed air, with violence and noise, blew out of the stem into the jar about ten inches of water; which was somewhat more (between half an inch and a whole inch, by reason of the *impetus* of the self-expanding air) than the space possessed by the air, before it began to be compressed. And besides this, such a strange multitude of bubbles, that were formerly repressed, did now get liberty to ascend from the lower parts of the glass to the top of the remaining water, that it somewhat emulated that, which happens to bottled beer, upon the taking out of the cork. *N. B.* when the air was compressed beyond seven inches, we observed divers times, that the inside of the glass possessed by the air, and nearest to the water, was round about, to a pretty height, full of very little drops like a small dew; but when we came to break the glass, we took no such notice, whether the rising water had licked them up, or their concourse made them run down into it, or for some other reason, we determine not.]

Another.

[5. WE took a single phial filled with water, about half an inch above the lower part of the neck, and leaving about two inches of air in the remaining part of the neck, which was drawn out in a slender pipe, like that of the glass last mentioned, we sealed it up, the air being first well cooled; and exposing it to freeze, we observed a while after, that it had by guess condensed the air into lesser room. A while after, being in another chamber, we heard a considerable noise, and imagining what it was, we went directly to the glass, whose upper part consisting of about an inch of the neck, besides the slender pipe, we found had been blown off from the table upon the ground, the body and part of the neck remaining in the snow; but this glass was of a metal, that uses to be more brittle than white glass.]

December
13.

Another.

[6. A ROUND white glass, almost filled with water, was sealed up with care, to avoid heating the included air, which amounted to a cylinder of about 2 inches and $\frac{7}{8}$; after a while the water swelled and compressed the air almost two inches, that is, full two thirds: and then (as we conjectured, because the snow reaching too high, froze it in the neck) we found the glass cracked in many places of the ball, and the top thrown off at some little distance from it.]

Another.

[7. A LARGE single phial sealed, in whose neck the air was not condensed to half its former room, just as we were going to break it under water, to observe the fall of the compressed air, suddenly blew off with a good noise, and threw from the table almost the whole neck of the phial in one intire piece, which is near four inches long, and at the basis above an inch broad.]

[8. A GLASS about the bigness of a turkey-egg, and of an oval form, with a neck almost cylindrical, but somewhat wider at the lower than the upper part, was filled with water, till there was left in the neck four inches and a half; whereof the last quarter of an inch, and a little more, was much narrower than the rest, being drawn into a conical shape, that it might be easily sealed at the apex; along this cylinder, from the surface of the water to the top of the glass, was pasted a list of paper, divided into inches and quarters: and then the glass being carefully and expeditiously sealed up by the flame of a candle, we observed, that by holding the glass a while in a warm hand, and a room, where there was a good fire, the water was swelled up near a quarter of an inch; but placing the glass amongst solid pieces of ice mixt with salt, the water quickly began to subside upon the infrigidation; and a while after beginning to freeze, it began to swell, and by degrees compressed the air, till it had crouded it into less than a 17th part, by what seemed indisputable; for by estimate, it seemed to some to be crouded into less than a 20th part, if not a much lesser part, of the room it formerly possessed. Which difference of estimates, notwithstanding the divided paper, proceeded from the change of the figure of the upper end of the glass, from the cylindrical, and to shew there was no leak at the place where the glass was sealed; besides that by prying diligently, we could discern none; besides this, I say, when the pressure of the thus crouded air grew too strong for the resistance of the glass, it burst with a noise, that made us come to it from several places of the house. The vessel broke not in the cylindrical part (as I may so speak) but in the oval, the whole pipe with the sealed end remaining entire; the ice appeared full enough of bubbles, which made it white and opacous, and the water, that had ascended into the neck, upon the breaking was all driven out of it.]

Thus far our collections; but because we had in another glass, where the operation was sooner dispatched, an opportunity of watching and observing somewhat more exactly, we will add,

9. THAT the last, and possibly the best experiment we had of compressing air by freezing, was made in a short and strong glass-egg, whose ball was very great in proportion to the stem, that the expanding of the water might have the more forcible operation. This vessel being exactly sealed, and having a divided list of paper pasted along the stem, was set to freeze with snow (or ice) and salt, and the contained water did quickly begin to croud the air into a lesser room, and for a good while ascended very fast; till at length it having thrust the air into so small a part of the cavity of the pipe, that we vehemently suspected there might be some unheeded flaw or crack of the glass, at which the air had stolen out, we drew near the vessel, and attentively prying all about it, to try, if we could discover any ground of our suspicion, we found (as far as the divided list, and other circumstances could inform us) that the air (supposing none of it to have got away) was reduced by our estimate into the 19th part of the space it possessed before. And this our curiosity proved not unseasonable; for whilst we were narrowly surveying the glass, to spy out some flaw in it, we were quickly satisfied there had been none, by a huge crack made upon the eruption of the included air, whose spring being, by so great a compression, made too strong for the

the glass to resist, it did with a great noise break the ball of the glass into many pieces, throwing the unfrozen part of the water upon me, and also throwing off the stem of the egg, which yet I had the good fortune to recover intire, and which I yet keep by me as a rarity.

10. THUS far we then proceeded in compressing the air, which being done in vessels hermetically sealed, where no air can get in or out, seems to me a more unexceptionable way than those, that have hitherto been thought of. But further, we could not then prosecute it for want both of convenient glasses, and of ice or snow, of which if we were provided, and particularly of strong glasses, we should little doubt of reducing the air to a yet more considerable degree of compression.

11. WE may add on this occasion, that we looked upon the same way, as somewhat less unpromising than others, that have been hitherto used to try the compression of water: for though hitherto neither the experiments of ingenious men, nor those made by our selves, have fully satisfied us, that water admits any more compression, than it may suffer upon the account of the little parcels of air, that are wont to be dispersed among it; yet the unsuccessfulness may perhaps (for I propose it but as a mere conjecture) be imputed to the porousness of the vessels; wherein, by the ways already practised, the experiment must be made: whereas in this new way of ours, not only the force, wherewith the compressed air presses upon the water, grows at length to be exceeding great, and is applied not with a sudden impetus, as when a pewter vessel is knocked with a hammer, but by slow and regular degrees of increase; but the water is kept in a vessel impervious to its subtlest parts, so that it may indeed crack the glass, but cannot get out at the pores, as the water compressed is wont to do at those of metalline vessels. The prosecution of this experiment, to bring it to any thing of accurateness, we omitted, partly through forgetfulness and avocations, and sometimes for want of conveniency to try it. But by the first of the lately mentioned experiments, about the condensation of air, it seems by the strong multitude of bubbles, which upon the breaking of the glass appeared in the water, that had been compressed betwixt air and the ice, that those two bodies had very violently compressed it. And this we are the more apt to believe, because that another time, when we had sealed up some air and water in a glass-egg, and permitted the water to swell by the operation of the cold, but till it had reduced the air, included with it, to about three quarters of the space it possessed before; even then (I say) to try, whether the subjacent water were not also compressed by the air it urged, we broke off the sealed apex of the glass, and perceived, as we expected, the water to ascend, and that to the height of a quarter of an inch, as we found by measure. But such trials having not been, as we just now acknowledged, duly prosecuted, we shall at present content ourselves to have named this way of attempting the compression of water, without grounding any inferences upon it.

T I T L E XIII.

Experiments and observations touching the sphere of activity of cold.

I. THE sphere of activity of cold, or, to speak plainer, the space, to whose extremities every way the action of a cold body is able to reach, is a thing very well worth the enquiring after, but more difficult to find, than at first one would imagine. For to be able to assign the determinate limits, within which, and not beyond them, a cold body can operate, several things are to be taken into consideration: as first, what the degree of cold is, that belongs to the assigned body. For it

seems rational to conceive, that if a cold body, as such, have a diffusive virtue, those, that have greater degrees of cold, as ice and snow, will be able to diffuse it to a greater distance, as we see, that a coal of fire will cast a sensible heat much further than a piece of wood, that is heated without being kindled. Secondly, the medium, through which the diffusion is made, may help to enlarge the bounds, or straighten the limits of it, as that medium is more or less disposed to receive or to transmit the action of the cold agent. Thirdly, Not only the consistence, and texture of the medium, but its motion, or rest, may be considered in this case. For in frosty and snowy weather, men observe the winds, that come from frozen lands, to blow more cold, than winds from the same quarter would do, in case there were no ice nor snow in their passage. Fourthly, There may be made very differing estimates of the diffusion of cold, according to the instrument, that is employed to receive, and acquaint us with the action of cold. For a liquor or other body may not appear cold to him, that examines it with a weather-glass, whilst he shall feel it cold with his hand; and as we elsewhere also note, to that sensory it self, as it is variously disposed, the same object will seem more or less cold; so much may the predisposition of the organ impose upon the unskilful or unwary. Fifthly, The very bulk of a cold body may very much enlarge or lessen its sphere of activity, as we may have occasion to shew ere long. And besides, there may be divers other things, that may render it very difficult to ascertain any thing in this matter. And therefore I shall reserve them for other opportunities, and observe now in general, that in such small parcels of ice itself, as in our experiments we are wont to deal with, we have found the sphere of activity of cold exceeding narrow, not only in comparison of that of heat in fire, but in comparison of the atmosphere, if I may so call it, of many odorous bodies; as musk, civet, spices, roses, wormwood, assa dulcis, assa foetida, castoreum, camphire, and the like; nay, and even in comparison of the sphere of activity of the more vigorous load-stones: insomuch that we have doubted, whether the sense could discern a cold body, otherwise than by immediate contact.

2. AND to examine this, having taken a piece of ice, we did not find upon trials, that I partly made my self, and partly caused in my presence to be made by others, that if a man's eyes were close shut, he could certainly discern the approach of a moderately-sized piece of ice, though held never so near his fingers ends. Nay, which is more considerable, having had the curiosity to make the trial, with one of those very sensible thermoscopes I have formerly mentioned (wherein a pendulous drop of liquor plays up and down in a slender pipe) I found, that by holding it very near to little masses of snow (somewhat compacted too) the moveable drop did not betray any manifest operation of so cold a neighbouring body; but if the glass were made to touch the snow, the effect would then be notable, by the hasty descent of the pendulous drop, or its motion towards the obtuse part of the instrument, in case that were not perpendicularly, but laterally applied to the snowy lumps. But this languidness of operation may perhaps proceed in great part from the smallness of the pieces of ice, that were employed; for hearing of a merchant, that had made divers observations about cold in *Greenland*, I desired, by the mediation of a very learned friend, to be informed, whether or no in the night they could perceive those vast heaps, or rather mountains of ice, that are wont to float up and down in that sea, by any new and manifest accession of cold, and was informed by way of answer to that question, that being at sea, they could know the approach of ice, as well by the increase of cold, as by the glaring light which the air seemed to receive from the neighbouring ice.

3. But

3. BUT that, which makes me suspect, that there may in this account be some mistake, is, that I have not yet met with any like observation in any of the voyages into gelid climates, that I have had occasion to peruse, though in some of them the navigators frequently mention their having met with vast rands (as some call them) and islands of mountainous ice in the night. And it is, as I remember, the complaint of one or two, if not more of them, that the ship lay close by such vast pieces of ice, without their being aware of it, by reason of the fogs. By which it seems, that there was no sensible cold diffused to any considerable distance, whereby they might be advertised of the unwelcome neighbourhood even of so much ice, but possibly the approach of far smaller masses of ice would have been sensible to them in such a climate as ours, where the organs would not have been indisposed to feel, by a long accustomance, any thing of near so intense a degree of cold, as that which then reigned in those northern seas.

4. WHILST we were considering the difference betwixt the operations of even the coldest bodies at the very nearest distance, and upon immediate contact, we thought it an experiment not altogether unworthy to be tried, whether, though ice and snow alone, that is, unassisted by salts, would not in some of our formerly mentioned experiments freeze water, through the thickness even of a thin glass, they may not yet do it when the water is immediately contiguous to them. And I remember, that we took a conveniently shaped glass, and having frozen the contained water for some hours, from the bottom upwards, till the ice was grown to be of a considerable thickness, we marked what part of the glass was possessed by the unfrozen water; and then removing the vessel to a little distance from the snow, and salt, it stood in before, we let it rest there, to try whether the ice would freeze any part of the contiguous and incumbent water; but some intervening accidents hindered us from being able to derive any great satisfaction one way or other from our trial.

5. WHEREFORE we shall add, by way of compensation, that the diligent *Olearius* relates, that at *Ispahan*, the capital city of *Persia*, though it be seated in a very hot climate, and though it seldom freeze there above a finger thick, and the ice melt presently at sun-rising, yet the inhabitants have conservatories, which they furnish with solid pieces of ice of a good thickness, only by pouring at night great store of water, at convenient intervals of time, upon a shelving floor of free-stone or marble; whereon, as the water runs over it, the most disposed of its parts are in their passage arrested, and frozen by the contiguous ice, which by this means (says my learned author) may be brought in two or three successive nights to a very considerable thickness.

Voyage de
Moscovie &
de Perse,
Liv. V.

6. WE several times gave order to have this experiment tried in *England*; but partly through the negligence of those we employed, and partly upon the score of intervening circumstances, our expectation was but ill answered. And in this case I mention *intervening circumstances*, because having caused a servant to pump in the night, upon a not very thin plate of ice, that was laid shelving upon a board, and another flat piece of ice being about the same time laid under a place, where water derived from a neighbouring spring is wont continually to drop, he brought me word, that not only in this last named place, the ice melted away, but that under the pump, instead of increasing in thickness by the waters running over it, it was thereby rather dissolved. At which somewhat wondering, I went in the morning myself to the pump, and causing a good piece of ice to be in a convenient posture placed under it, I observed the water, as it came out of the pump, and was falling on the ice, to smother, as if the depth of the well had made the water, though very cold to the touch,

touch, somewhat warm in comparison of the ice, and thereby fitter to dissolve than to increase it; (which inconvenience may be prevented by suffering the water of deep springs and wells to stand to cool in the air, before it be put to the ice) and this, though the neighbouring air were, as I found by manifest proofs, so cold, that I was not tempted to impute the unsuccessfulness of the experiment, rather to its want of a sufficient coldness, than the water's. So that till I have an opportunity of making a further trial, I cannot say more to the *Persian* way of augmenting ice. But to proceed: Our having met with but an unsatisfactory account of this experiment, which we were the more troubled at, because this seemed a promising way of trying that, which otherwise is not so easily reduced to experiment; for the temperature of the air must be seriously considered in assigning the cause of divers trials, that may be made for the resolving of the same question: For to omit other examples, here in *England* we find, that water poured on snow is wont to hasten the dissolution of it, and not to be congealed by it; whereas having inquired of an ingenious person, that lived a good while among the *Russians*, he informed me, that it was their usual way to turn water and snow into ice, by pouring a convenient proportion of that liquor into a great quantity of snow: and having also inquired, whether ice had not the like operation, he told me, that it was usual, and he had seen it practised in *Muscovy*, to cement ice to buildings, and other things, and also to case over bodies, as it were, with ice, by gradually throwing water upon them. But I doubt, whether that effect be to be ascribed barely to the contiguity of ice, because I learned of him, that this way of increasing ice is practised in very frosty weather, when water thinly spread upon almost any other body would be frozen by the vehement sharpness of the air.

7. THE glaciations, that nature unguarded by art is wont to make, beginning at those parts of bodies, at which they are exposed to the air; it usually happens, that they freeze from the upper towards the lower parts. But how far in earth and water (the most considerable bodies, that are subject to be frozen) the frost will pierce downwards, though, for some hints it would afford, worth the knowing, is not easy to be defined; because the deepness of the frost may be much varied by the degree of coldness in the air, by which the glaciation seems to be produced, as also by the greater or lesser duration of the frost, by the looser or closer texture of the earth, by the nature of the juices, wherewith the earth is imbued, and by the constitution of the subjacent and more internal parts of the earth, some of which send up either actually warm, or potentially hot and resolving steams, such as those, that make corrosive liquors in the bowels of the earth; so that the frost will not seize upon, or at least cannot continue over mines. And I have seen good large scopes of land, where vast quantities of good lime-stone lay near the surface of the earth, on which I have been assured by the inhabitants, that the snow will not lie. There are divers other things, that may vary the depth, to which the frost can penetrate into the ground, (I say, into the ground, because in most cases it will pierce deep into the water) but yet, that we may not leave this part of the *History of Cold* altogether uncontributed to, we will add some of our notes, whereby it will appear that in our climate the frost pierces far less into the ground, than many are pleased to think.

8. THE notes I find about this matter are these that follow, which I transcribed unaltered, because it were tedious, and not worth while to add the way we employed, and the cautions we used in making the observations; but we shall rather intimate, that the following trials were made in a village about two miles from a great city.

[I. AFTER four nights of frost, that was taken notice of for very hard, we went Jan. 22. into an orchard, where the ground was level, and not covered with grafs, and found by digging, that the frost had scarce pierced into the ground three inches and a half. And in a garden nearer the house, we found not the earth to be frozen more than two inches beneath its surface.]

II. NINE or ten nights successive frost froze the grafsless ground in the garden, about six inches and a half, or better in depth, and the grafsless ground in the orchard, where a wall sheltered it from the south sun, to the depth of about eight inches and a half, or better.]

[WE digged in an orchard near a wall, that respects the north, and found the frost Feb. 9. to have pierced the ground about a foot and two inches, at least above a foot: this is the eighth day since it was about eight inches and a half.]

[A SLENDER pipe of glass, about 18 inches long, and sealed at one end, was thrust over night into a hole, purposely made with a spit straight down into the ground, the surface of the water being in the same level with that of the earth; the next morning the tube being taken out, the water appeared frozen in the whole capacity of the cylinder, but a little more than three inches. But from this stick of ice, there reached downwards a part of a cylinder of ice of about six inches in length, the rest of the water remained unfrozen, though it were an exceeding sharp night, preceded by a constitution of the air, that had been very lasting, and very bitter. The earth in the garden, where this trial was made, we guessed to be frozen eight or ten inches deep, as it was in another place about the same house. But, if this tube had not been in the ground, the ambient air would have frozen it quite through.]

9. ANOTHER note much of the same import, we find in another place of our collections.

FINDING, that by reason of the mildness of our climate, I was scarce to hope for any much deeper congelation of the earth or water, I applied myself to inquire of an ingenious man, that had been at *Mosco*, whether he had observed any thing there to my present purpose, as also to find in captain *James's* voyage, whether that inquisitive navigator had taken notice of any thing, that might inform me, how far the cold was able to freeze the earth or water in the island of *Charleston*, where that quality may probably be supposed to have had as large a sphere of activity, as in almost any part of the habitable world. And by my inquiries I found, that even in frozen regions themselves, a congealing degree of cold pierces nothing near so deep into the earth or sea as one would imagine; for the traveller I spoke with, told me, that in a garden in *Mosco*, where he took notice of the thing I inquired about, he found not the ground to be frozen much above two foot deep. And in captain *James's* journal, page 63. the most that I find (and that too, where he gives an account of the prodigiously tall ice they had in *January*) concerning the piercing of the frost into the ground, is this, that *the ground at ten foot deep was frozen*. Whence by the way we may gather how much sharper cold may be presumed to have reigned in that island, than even in *Russia*. And as for the freezing of the water, he does in another place occasionally give us this memorable account of it, where he relates the manner of the breaking up the ice in the frozen sea, that surrounds the island we have been speaking of: 'It is first to be noted (says he, page 86.) that it doth not freeze (naturally) above six foot; the rest is by accident; such is that ice, that you may see here six fathom thick. This we had manifest proof of, by our digging the ice out of the ship, and by digging to our anchors before the ice broke up.' The rest of that account not concerning our present purpose, I forbear to annex; only taking

taking notice, that notwithstanding our lately mentioned experiment of freezing water in a glass tube thrust into the ground, yet it seems, that at least where captain *James* wintered, the water was not much above half so thick frozen as the earth. But we have already noted the indisposition of salt water to congelation; and whether fresh water would not have been deeper frozen, may be justly doubted.

TITLE XIV.

Experiments touching the differing Mediums, through which cold may be diffused.

1. **I**N examining whether cold might be diffused through all mediums indefinitely, notwithstanding their compactness, or the closeness of their texture, we must have a care not to make our trials with mediums of too great thickness, lest we mistakingly impute that to the nature of the medium, which is indeed caused by the distance, which the medium puts betwixt the agent and the patient. For the mixtures of ice and snow, wherewith we made our experiment, will operate but at a very small distance, though the medium resist no more than the common air, as may appear by some of the experiments recorded in this treatise.

THIS premised, we may proceed to relate, that having placed a copious mixture of ice and salt in pipkins glazed within, and in white basons glazed both within and without, we observed, that the outside of both those sorts of vessels was cruisted over with ice: though, however the baked earth had not been compact, nor the vitrified surface of a very close texture; the very thickness of the vessels was so great, that it seemed it would scarce have been able to freeze at a greater distance.

2. BY the experiments formerly mentioned of freezing water in pewter bottles, it appears, that cold is able to operate through such metalline vessels.

3. AND this may be somewhat confirmed by one of the prettiest experiments, that is to be performed by the help of cold, namely, the making icy cups to drink in. The way we used was this; we caused to be made a cup of latten (by which I mean iron reduced into tin plates, and tinned over on both sides) of the shape and bigness I intended to have the cup of; then I caused to be made of the same matter another cup of the same shape with the former, but every way less; so that it would go into the greater, and leave a competent interval for water betwixt its convex surface, and the concave of the other. This innermost cup was furnished with a rim or lip, by which it leaned upon the greater, and by whose help its sides and bottom were easily placed at a just and even distance from the sides and bottom of the other; but the distance between the two bottoms is made greater, than that between the sides, that the icy cup might stand the firmer, and last the longer. The interval between the two parts of this mould being filled with water, and the cavity of the internal cup being filled with a mixture of ice and salt, (partly to freeze the contiguous water, and thereby cooperate to the quicker making of the cup, and partly by its weight to keep the water from buoying up so light a cup) the external part was surrounded with ice and salt, whose cold so powerfully penetrated to the internal metalline mould, that the water was quickly frozen, and (the parts of the mould being disjoined) appeared turned into an icy cup of the bigness and figure designed. And these cups being easily to be made, and of various shapes (and that in the midst of summer, if snow or ice be at hand) are very pleasant trifles, especially in hot weather, when they impart a very refreshing coolness to the drink poured into them; and though they last not long, especially if they be employed to drink wine, and such like spirituous drinks in, yet whilst some are melting, others may be provided, and so the loss may

be easily repaired. All the difficulty we met with, was to disjoin the parts of the mould, which are wont to stick very fast to the ice they include: and we tried to obviate this, sometimes by anointing the inside of the mould with some unctuous and not offensive matter, to hinder the adhesion of the ice, and sometimes by applying some convenient heat both to the convex part of the external, and the concave part of the internal piece of the mould; which last mentioned way is quick and sure, but lessens the durableness of the cup.

[WE were lately informed, that this way of making cups of ice, is set down in *Barclay's Argenis*, and it is like enough, that ingenious man may have learned it amongst some of the virtuosi of *Italy* he conversed with: but if we, that learned it from none of them, had not been taught it by experience, we should scarce have ventured to try it upon the credit of a romance; that sort of composures being wont to be fabulous enough to pass but for poems in prose.]

4. THE learned and industrious mathematician *Erasmus Baribolinus* mentions in his newly-published discourse *de Figurâ Nivis*, an experiment, by which he tells us, that some masters of nature's secrets do easily, even in the midst of heat, reduce air into water. For they put a little snow or ice into a funnel, and thereby so refrigerate and condense the ambient air, that there will dew trickle down the sides of the funnel: by which means it has been said, that some ingenious men have hoped to make an artificial fountain in the midst of summer. But I here mention this experiment rather, because it is not unlikely to please those, to whom it is new, and because having purposely tried in large and thick funnels of glass, it may be pertinently enough delivered in this place, (where we are treating of the transmission or propagation of cold through close and thick mediums) than because we expect to make of it that use, especially that oeconomic use, that has been lately intimated. For first, it will be very hard to prove, that it is the very air itself, and not rather the vapours swimming in it, that are by this means transmuted into water. And secondly, it is true indeed, that a mixture of snow and salt will condense vapours on the outside of a funnel; but either they, that hoped to make this use of the experiment, have little experience of it, and write conjecturally, or else they have made it with a success very differing from ours. For though we employed a large funnel, and suspended it by a string (artificially enough tied about it) in the free air; and though the mixture of ice and salt we put in, were sufficiently infrigiding (as will appear by and by) and far more so, than ice or snow alone would have been; yet that mixture being not able to condense the vaporous parts of the air into dew, much, if at all, longer than the mutual dissolution of the salt and snow lasted, the liquor, that was this way obtained, and dropped down at the bottom of the funnel (whose internal perforation ought to be carefully stopped, lest any of the resolved snow and salt should fall through, and spoil the other liquor) was indeed sweet like rain-water, but so very little, as well as so slowly generated, that it amounted not any thing near to that, which the snow employed, and spoiled to make it, would have afforded. So that it may be questioned, whether some cooling liquors, which can as well as this mixture condense the vapid air into water, and whose texture is not destroyed in this operation, as that of the snow is, might not be more hopefully employed to obtain water from the air; to which I shall only add this one thing, that the mixture of snow and salt did turn the vapours, that fasten themselves to the outside of the glass, first into ice, before they drop down in the form of water, in almost all our trials of this nature, as well in thick funnels, as in other, and thinner glasses.

5. THAT in hermetically sealed glasses, an included mixture of snow and salt will freeze the vapours of the air on the outside of the glass, divers of the experiments of

the present treatise do manifestly evince; which argue, that even so extremely close a medium as glasses is not able to hinder the transmission of cold. And this is not superfluously added, because in vessels not hermetically sealed, it may be pretended, that it is the internal air, that communicates its coldness by some unheeded, but immediate intercourse, with the external.

AFTER this we thought it worth an experiment, to try, whether, or how, cold would be diffused through a medium, that some would think a vacuum, and which to others would seem much less disposed to assist the diffusion of cold, than common air itself. To compass this, the expedient we bethought ourselves of, was to suspend a slender glass full of water in one of the small receivers belonging to our pneumatical engine; and when the air was very carefully pumped out, to bury the exhausted receiver in a copious and ready prepared mixture of ice and salt, to see whether, notwithstanding the withdrawing of the medium, the water suspended in a kind of vacuum, as to air or gross substances, would yet be frozen by the cold. That event of our trials, which alone I find among my notes, is registered in these terms.

6. [A SMALL pipe, sealed at one end, was, at the other, filled almost with water, and was put into a receiver, consisting of a somewhat long and slender tube of glass, sealed at one end, and inverted upon the engine plate; then the air was carefully exhausted, and the pump was plied; a while after no air appeared to come forth in any bubble out of the receiver, through the external water: nor did the water in the small pipe within disclose any number of bubbles worth taking notice of: then by the help of an almost cylindrical plate of iron, beaten ice and salt were heaped against the outside of the receiver, about the height, to which the water in the small pipe reached. And at length, though, as we all thought, much more slowly than such a congelation would else have been performed, the water was for the most part frozen in odd kind of flakes from the top to the bottom, and the ice seemed not to have any considerable number of bubbles.]

7. THERE is one experiment, I have made about the transmission of cold through indisposed mediums, which may not be unworthy to be here inserted. For I had once a mind to try, whether a cold body could operate through a medium, that was, as to touch, actually hot, and had its heat continually renewed by a fountain, as it were, of heat, that perpetually diffused through it new supplies of warm liquor; so that the cold body could not here, as in other cases, first allay the heat of the medium, and then lessen it more and more, till it had quite extinguished it. To compass this, I had soon after an opportunity of making some trials presented me: for being at the mineral springs at *Tunbridge*, to drink those wholesome waters for my health's sake, I soon accustomed myself to drink them in considerable quantities very early in the morning, when they were exceeding cold, and sometimes drinking them in bed, as well as sometimes at the spring's head, I had the curiosity to observe, whether, in case I took them down very fast, they would not through the warm muscles and outward parts of the abdomen, diffuse a sensible coldness: and upon more trials than one, I found, that by laying my warm hands on the outside of my belly, I there felt, at least as it seemed to me, a manifest and considerable degree of coldness. And when I related this to some ingenious persons, that were better acquainted with those springs than I, they told me, that there was among those many, that then resorted to those famous springs, a knight, whose name I remember not, whose disease being judged formidable, the physicians enjoined him to drink in a morning two or three times the quantity, that afforded me the observation I was relating; and that when this knight had filled his belly with so much water, he used mightily

mightily to complain of the coldness it diffused through his abdomen, insomuch that he was fain to ply those parts long with hot napkins clapped to them, one after another; which yet, as he complained, were soon refrigerated by the excessive cold, that the water diffused to the outside of his belly; which yet nevertheless was not, that I could learn, at all prejudiced, no more than mine, by so sensible and piercing a cold.

8. It may be doubted, whether in case water be not fluid upon the account of a congenite motion in the corpuscles it consists of, its fluidness may not proceed from the agitation of the ambient air, either immediately contiguous to the surface, or communicating its agitation to the water, by propagation of its impulse, through the vessel, that interposes betwixt them. To contribute to the clearing of this, and some other things, we devised the following experiment: We provided a glass-bubble, of about the bigness of a walnut, and the form almost of a pear, whose stem was purposely made crooked for the conveniency of suspension. This being filled with water (which is troublesome enough to be done, unless one have the knack) we hung it at one end of a thread, whose other end we past through a cork, by a perforation purposely made; into which we afterwards fastened a thread, by thrusting in a small peg to rivet it in. Then filling a glass not very broad, but yet furnished with a mouth wide enough to receive the bubble, with oil of turpentine, such as we bought it at the shops, we stopped the orifice with the newly mentioned cork; so that the sealed bubble hanging as it was covered, and every way surrounded by the oil of turpentine; which being a liquor, that (at least in some colds as we here have) will not freeze, we placed the glass in beaten ice and salt, and as it were buried it therein: and at the end of about three hours (having been diverted by some occasions from taking it sooner out) we found, as we had conjectured, that, notwithstanding that, the oil of turpentine, continued perfectly fluid as before, yet the bubble totally immersed in this heating chymical oil was frozen throughout, not excepting that, which was harboured in the little neck or stalk; and when I came to lift it out of the liquor, the glass being cracked (as we supposed by the cold) the string brought up a little part of that, which was nearest to it; the rest in the form above-mentioned staying behind and subsiding. And that, which was remarkable in this piece of ice, was, that when we had taken it out, it appeared cleft very deep (from the outside almost to the centre) according to a line drawn from the slenderest part of it, almost as if one should with a knife cut a pear in two, from the stalk downwards, according to its whole length. And these two pieces were easily enough separable, and (to add that circumstance) for trial sake we left them divided in the same liquor and vessel, with some thawing ice and salt about them, for 14 or 15 hours, without finding them any thing near so much wasted or resolved into water, as most would have expected.

WHILST the above-mentioned vessel was exposed to be frozen, we likewise placed by it another vessel, a glass-egg, whose ball and a little part of its stem we had filled with some of the very same parcel of oil of turpentine; and placing about the sides of the egg some ice and salt, we observed, as we expected, that the liquor was, after a little while, made by the cold to subside about half an inch: so that it is worth some philosophers considering, why, if according to the lately mentioned atomical doctrine, cold be made by the introduction of swarms of real and extended, though atomical bodies, they should pervade the oil, and contract it without freezing it, but freeze the water without contracting it, but expanding it rather.

9. [A small bubble of the bigness of a very little nutmeg, filled with water, and hermetically sealed up, was by a cork and a string suspended in spirit of wine, so as to be surrounded therewith; and being exposed to the air the same night, in the stopt

glass, was the next morning found altogether frozen, though the spirit of wine it self were not at all so: but another bubble, by the help of a string cork, and piece of lead, carefully suspended in a strong solution of sea-salt, and exposed at the same time in a like vessel with the former, when they both came to be looked upon, appeared to be no more frozen than the brine it self, which was not so at all.]

10. [A GLASS bubble of the bigness of a small nutmeg, filled with water, and hermetically sealed, being immersed by a weight of lead fastened to it, beneath the surface of a very salt brine, but yet not so as to reach the bottom of the liquor or glass, was exposed all night to freeze, in weather, that was extraordinarily cold; but neither the imprisoned water, nor the other appeared to be at all frozen. The like experiment we repeated another frosty night, but without freezing either of the liquors. But to shew the usefulness of repeating experiments about cold, if there be opportunity, and especially in such cases, where the degree or some other circumstance may much vary the event, we will add, that having exposed a bubble like that newly mentioned, and immersed in spirit of wine, we found the next morning the water in the bubble turned into ice; and having likewise exposed such a bubble immersed in very strong brine, to be frozen by a mixture of ice and salt, within about two hours after, we found the bubble broken, as we supposed, upon the expansion of the water upon its growing ice. And we also found the upper part of the bubble with the ice sticking to it, and the other part of the glass was cracked, with lines running from a point almost like the pole and meridian in a globe; whence we concluded the glass to have been, as it is probable, burst asunder upon the expansion of the fresh water into ice; and that the reason, why there remained but a comparatively little parcel of ice, was probably, that the salt water getting in at those crannies or chinks, dissolved as much of the new-made ice, as in a little while it could easily reach.

Besides;

11. [WE filled a glass bubble with fair water, and having hermetically sealed it, we suspended it by a string fastened to the cork in the cavity of a wide-mouthed glass well stoppt, so that the bubble was every way at a good distance from the sides, bottom, and top of the glass. This we did to try, whether a sufficient degree of cold at that distance would be freely transmitted through the glass, without the intervention of a visible liquor; and accordingly we found the suspended bubble cracked by the ice, that filled it.]

T I T L E X V.

Experiments and observations touching ice.

1. A GREAT part of our present history being employed about delivering the phenomena of congelation, it is not to be expected, that in this section, where we treat of ice as a distinct part of our theme, we should deliver all those particulars, that have occurred to us, wherein ice is concerned. And therefore we shall restrain our selves to the mention of those, that belong to ice, considered, as it consists of intire and distinct portions of congealed water. And though we shall deliver some few experiments of our own, such as we had any opportunity to make, yet much the greater part of this section will fitly enough be taken up by collections out of travellers, and navigators, into those colder regions, that afford much considerable, or at least much stranger observations concerning ice, than are to be met with in so temperate a climate as ours. And what we have to deliver in this section will naturally be divided into two parts, the one consisting of our own experiments, and the

the other containing some passages, that we have selected out of voyages, or that have been afforded us by the relations of credible travellers. And of these two sorts of observables, that, which has been first mentioned, shall be first treated of.

2. SOME, that have been in the *East-Indies*, inform us, that in some parts of those countries they were looked upon as great liars, for affirming, that in *Europe* the fluid body of water was often without any artifice or endeavour of man turned in a few hours into a solid and compact body, such as ice. And certainly, if custom did not take away the strangeness of it, it would to us also appear very wonderful, that so great a change of texture should be so easily and inartificially produced. But how solid the body of ice is, or rather how strong is the mutual adhesion of its parts, has not yet, that we know of, been attempted by experiments to be reduced to some kind of estimate: and indeed so many things must be taken into consideration, that it will be difficult to arrive at any more than a fair conjecture in this matter; especially, because (I think) it may justly be doubted, whether or no differing degrees of cold may not vary the degree of compactness of the ice. And my doubt will not perhaps appear groundless, if I add, that having, to satisfy my self, inquired of an intelligent person, that lived some years in *Russia*, he answered me, that he found the ice of those parts to be much harder than that of these.

3. WE had in our thoughts divers ways to estimate the cohesion of the parts of ice, whereof one was, to freeze water in a hollow metalline cylinder, and taking out the ice, and keeping it in a perpendicular posture, cast into a scale weighed beforehand, and carefully fastened to the bottom of the ice, more and more weight, till the mere weight broke the cylinder: and this we had thoughts to try in cylinders of differing diameters and lengths, but wanted conveniencies to make the experiments; (which if they were made, as some of our trials were, in the open air, and in places exposed to some gelid wind, it would the better secure the ice from being weakened or thawed during the trials.)

4. WE therefore attempted, by another way, to investigate the strength of ice. For we took a plate of it, of an uniform, and also of a considerable thickness, and with sides cut parallel, that it might serve for a kind of lever, and placed it betwixt two wooden bars, whose distance we knew; and then laying on it a great weight, the centre of whose pressure, as near as we could estimate, was equally, or in determinate measures, distant from the wooden fulcrums, we endeavoured to try, how great a weight it would support; but in the village, where we made the trials, we could not get weights, that were conveniently shaped, and ponderous enough, to break it; and though we caused a man to stand upon it, yet neither could his weight break it; till he chanced to add an impressed force with his foot to the weight of his body. So that being unable to determine, what that additional and impressed force might amount to, almost all that we could safely conclude, either from this experiment, or some other ways of trial with scales, and other ways, that we made use of, (but for want of conveniencies unsuccessfully) was, that the force of ice to support weights is much greater than men can imagine; which seems somewhat the more strange, because it is not here in *England* so solid a body, as by this one would guess: for not only glass would readily scratch it deep enough, but even with common knives we could cut it, and that with great ease.

5. YET one not inconsiderable account I was able to give my self of the strength of ice, which I find in my notes thus delivered.

[THERE was taken a piece of ice three inches long, and three broad, and somewhat less than a quarter of an inch thick; this was laid cross-ways upon a frame, so that the two parts, on which the ice leaned, were distant three inches: then there was taken

taken an iron, shaped like the figure of (the common arithmetical cypher, that denotes seven) 7, to whose hanging leg, if I may so call it, there was fastened at the end, which was under the middle of the ice, a scale, into which several weights were put, such as by some former trials we guessed to be almost as much as the ice would well suffer: after which, the horizontal leg of the iron was very gently laid upon the ice, as near as we could guess, in the middle of the distance, between the two sides of the frame, and consequently parallel to them both. Then the weights not proving altogether sufficient to break the ice, we let them hang a while at it, and observed, how the edge of the incumbent leg of iron (which edge was * broad) did work it self downwards into the ice; so that by our guess, when the ice broke, as after a while it did, it had lost at one end of the incision, if I may so call it, half its thickness, and at the other, about a third part of it.

THE weights, that broke it, amounted to 17 pounds averdupois, and 117 ounces Troy.

6. THE experiment was repeated with all the former circumstances, only the piece of ice was two inches and a half broad, and a quarter of an inch thick, and the distance of the frame was three inches, as before; the weights, that broke it, were 17 pounds averdupois, and 41 ounces Troy. The horizontal arm of the iron had melted somewhat more than half through the ice when it broke, *viz.* more than $\frac{2}{3}$ of the thickness at one end, and somewhat less than half at the other.

7. WE divers times intimated in some of the first sections of our present history, that the addition of salt to ice did hasten the dissolution of it, which though it may be easily proved by some other phænomena of our experiments, yet it will not be amiss to mention here a couple of particular trials, by which we have more manifestly evinced it. And first, we divers times took a broad and flat plate of ice, less than a quarter of an inch thick, and having placed it horizontally upon a joint-stool, (a table, or any other flat piece of wood will do as well) we strewed here and there a convenient quantity of bay-salt upon it; and though we observed, that, if the surfaces of the ice and stool were not both of them flat, and congruous enough, the ice would be thawed indeed, but the other part of the experiment would not well succeed; yet when we made the trial carefully and watchfully, the plate of ice partly thawed by the salt would be so firmly frozen to the stool it leaned on, that we were fain with an iron instrument to knock it all to pieces, before we could sever it from the stool; into whose pores the ice newly generated by the experiment did pierce so deep, that, notwithstanding our knocking, many little parcels of ice would continue to stick close to the wood, whose pores they had invaded. But the circumstances, which in this experiment made the most to our purpose, are these two; the one, that having sometimes laid the salt but on a few, and somewhat distant parts of the plate, the intermediate parts would many of them remain unfrozen to the stool; whilst those, where the salt had been laid, were frozen so hard to it. And the other circumstance is, that the grosser grains of salt would so far dissolve the ice, whereto they were contiguous, as (if I may so speak) to bury themselves therein; whilst the other parts of the ice, upon which, or near which, no salt had been laid, kept their surfaces smooth and intire. We tried likewise two or three times to freeze a plate of ice to a flat piece of wood, by making use of aqua fortis, instead of common salt; but the experiment succeeded not well, though once we brought the ice to stick to the wood manifestly, but not strongly.

* The breadth was, I know not how, omitted in the note; but, as I remember, it was about an 8th part of an inch.

8. To this we shall add the following experiment, which, when we watchfully made it, succeeded well, and I find it among my notes set down in these terms.

[SOLID fragments of ice having pretty store of salt thrown on them, upon the first falling of the salt among the ice there was produced a little crackling noise, and for a good while after there manifestly ascended out of several parts of the mixture, conveniently held betwixt a candle and the eye, a steam or smoke, like that of warm meat, though the night were rainy and warm, and though the morning had not been frosty.]

THE mention here made of the crackling noise made by the ice upon the addition of salt, (which seemed to proceed from the crackling of the brittle ice, produced by the operation of the salt upon it) brings into my mind an experiment I had formerly made, whereof a greater noise of the same kind is a phaenomenon, though the experiment were chiefly made for the discovery of the texture of ice: the event of the trial I find thus set down among my notes.

9. [WE took some cakes of ice, each of the thickness between $\frac{1}{8}$ and $\frac{1}{4}$ part of an inch, but not so very compact ice, as to be free from store of bubbles: some good aqua fortis dropped upon this did quickly penetrate it with a noise, that seemed to be the cracking of the ice, underneath which the sour liquor was plainly to be tasted. Oil of vitriol did the same, but much more powerfully, and without seeming to crack the ice, which it past through; so that though but three or four drops were let fall upon the plate, it immediately shewed it self in drops exceedingly corrosive on the other side of the ice. And the like success we had with a trial made with the same liquor, upon three such plates of ice frozen one upon the top of another.]

10. HAVING proceeded as far as we were able towards the bringing the strength of ice to some kind of estimate, by such experiments as we had opportunity to make here, we thought it not amiss to seek what information we could get about this matter among the descriptions, that are given us of cold regions: but I have not yet found any thing to have been taken notice of to this purpose worth transcribing, except a passage in the archbishop of Upsal, wherein, though the estimate of the force of ice be, as we shall by and by shew, made after a gross manner, yet since this it self is more than I have met with elsewhere, I think it worth subjoining, as our author delivers it in these terms: *Glacies (says he) primæ & mediæ hyemis adeo fortis & tenax est, ut spissitudine seu densitate duorum digitorum sufferat hominem ambulantem, triam vero digitorum equestrem armatum; unius palmæ & dimidiæ, turmas, vel exercitus militares; trium vel quatuor palmarum integram legionem seu myriadem populorum, quemadmodum inferius de bellis hyemalibus memorandum erit.*

Olaus M.
Gent. Sep-
tentr. Hist.
l. 1. c. 14.

BUT though this be sufficient to afford us an illustrious testimony of the wonderful strong cohesion of the parts of ice, yet we mentioned it but as a popular way of estimate, which may better embolden travellers, than satisfy philosophers, in regard, that the author determines only the thickness of the ice, and not the distance of that part of it, that supports the weight from the shore or brink, on which, as on a hypomocion, the remotest part of the ice does lean or rest. And if we consider the ice as a lever, and the brink or brinks, on which it is supported, as a single or double fulcrum, the distance of the weight may be of very great moment in reference to its pressure or gravitation on the ice, which may more easily support the weight of divers men placed very near the prop, than that of one man placed at a great distance from it; as will be easily granted by those, that are not strangers to the mechanicks, especially to the nature and properties of several kinds of levers. But not now to debate, whether in certain cases, the ice we speak of, may not receive some support from the subjacent water, nor whether some other circumstances may not sometimes be able to alter the case a little, our very considering the ice as a single or double

lever,

lever, though it may hinder us from measuring the determinate strength of ice upon *Olaus's* observation, yet it will set forth the strength of it so much the more, since by his indefinite expressions he seems sufficiently to intimate, that when the ice has attained such a thickness, its resistance is equivalent to such a weight, without examining on what part of the ice it chanced to be placed.

II. Thus far our experiments concerning ice, with the appendix subjoined out of *Olaus* to the same purpose. We will now proceed to some of the observations we have met with in seamen's journals, and elsewhere. I say to some, because to enumerate them all, would spend more time and labour than I can afford; and therefore I shall restrain myself to the mention of some few of the chiefest.

I. AND in the first place for confirmation of what I delivered, at the beginning of this section, from the report of a traveller into *Russia*, touching the hardness of ice in those gelid climates, in comparison of our ice, which I have found it easy to scrape with glass, or to cut with a knife; I shall subjoin this passage of Captain *G. Weymouth*, in his voyage for the discovery of the North-west passage: 'As we were (says he) breaking off some of this ice, which was very painful for us to do, for it was almost as hard as a rock, &c.'

Purchas,
Lib. 4.
Chap. 13.

II. NEXT to shew, that it was not a superfluous wariness, that made me in a former section doubt, that even the ice made of sea-water might be altogether or almost insipid; I will subjoin, that I have since met with some relations, that seem to justify what is there delivered. And in one of our Englishmen's voyages into the Northern seas, I find more than one instance to my present purpose, though I shall here set down but one, which is so full and express, that it needs no companions; our navigator speaking thus; 'About nine of the clock in the forenoon, we came by a great island of ice, and by this island we found some pieces of ice broken off from the said island; and being in great want of fresh water, we hoisted out our boats of both ships, and loaded them twice with ice, which made us very good fresh water.'

Purchas,
Lib. 4.
cap. 13.
pag. 813.

BUT all this notwithstanding, I yet retain some scruple, till those, that have better opportunity to make a more satisfactory experiment, shall ease me of it. For though by these narratives it seems more than probable, that the ice in the midst of the sea consists but of the fresh particles of water, that plentifully concur to compose the sea water; yet besides that, in case the fresh water were taken, as some of that I have found mentioned in voyages, has confessedly been, from the top of the ice, it might possibly be no more than melted snow, which, as we elsewhere take notice, does in those extreme cold regions easily freeze upon the ice it falls on, and oftentimes much increases the height of it: besides this, I say, the argument from the insipidness of the resolved ice will conclude but upon supposition, that as that ice was found in the sea, so it was also made of the sea water; which though it may have been, yet I somewhat doubt, whether it were or no, since I find some navigators of the most conversant in the cold climates to inform us, that most of those vast quantities of ice, that are to be met with about *Nova Zembla*, and the strait of *Weigats*, and that choak up some other passages, whereby men have attempted to pass into the south sea, are composed of the accumulation of numerous pieces of ice (cemented by intercepted, and then frozen, water) that are brought down from the great river *Oby*, and others; so that it may very well be supposed, that these * mountainous pieces of ice may be some of those,

* Neither hereafter will I marvel, though the strait of *Weigats* be stopped up to the North-east, with such huge mountains of ice, since the rivers *Oby* and *Jenesce*, and very many more, whose names are not yet

those, which, upon the shattering of ice in bays and straits, partly by the heat of the sun, and partly by the tides, may be afterwards by the winds and currents driven all up and down the seas, to parts very distant from the shore; and some of these, it may be, that our countrymen met with, and obtained their fresh water from: which I the rather incline to think, because that (as we shall have occasion to observe in another section) the main sea it self is seldom or never frozen. But my scope in all this is but to propose a scruple, not an opinion.

III. THE next and principal thing concerning ice is the bigness of it, which I find, by the relations partly of some acquaintances of my own, and partly of some navigators into the North, to be sometimes, not only prodigious, but now and then scarce credible. And therefore, as I shall mention but few instances, that I have selected out of the best journals, and other writings I have met with, so I shall add a few more testimonies to keep them, by their mutual support, from being entertained with a disbelief, which their strangeness would else tempt men to.

OF the vastness of single mountains of ice, the most stupendous example, that, for aught I know, is to be met with in any language but ours, is that, which I formerly took notice of, out of the Dutch voyage to *Nova Zembla*, which was ninety-six foot high (that is, above twenty foot higher, than on a certain occasion I found the leads of *Westminster Abbey* to be.) But it is probable, that our Captain *James* met with as great, if not greater: for though in some places he mentions divers hills of ice, that were aground in 40 fathom water, and consequently were as deep under water, as that newly taken notice of out of the *Hollanders*, page 14: and though he elsewhere mentions other pieces of no less depth, and twice as high as his top-mast head, and this in *June*: yet elsewhere, and long after, relating his return home, he has this passage; page 106. ‘We have sailed through much mountainous ice, far higher than our top-mast head: but this day we sailed by the highest I ever yet saw, which was ‘incredible indeed to be related.’

BUT the stupendoudest piece (for height and depth) of single ice, that perhaps has been ever observed and measured by men, is that, which our famous English seaman Mr. *W. Baffin* (whose name is to be met with in many modern maps and globes) mentions himself to have met with upon the coast of *Greenland*, whose whole relation I shall therefore subjoin, not only because of the stupendousness of this piece of ice, but because he takes notice of an observation, which I knew not to have been made by any, and comes somewhat near the estimate we formerly made of the proportion betwixt the extant and immersed parts of floating ice; only the following estimate makes the extant part somewhat greater than we did; which may easily proceed from other men’s having, as Mr. *Baffin* here does, grounded their computation upon what occurred to them at sea, or in salt water, where the ice must sink less than in fresh water, such as my estimate supposed. Our navigator’s words then are these: ‘The 17th of *May* we sailed by many great islands of ice, some of which were above 200 foot high above water, as I proved by one shortly after, which I found to be 240 foot high; and if the report of some men be true, which affirms, that there

Purchas.
lib. 4. cap.
18. pag.
337.

yet known, pour out such a quantity thereof, that in a manner it is incredible: for it cometh to pass in the beginning of the spring, that in places near unto the sea, the ice, through the excessive thickness, and multitude thereof, doth carry down wood before it. And without doubt this is the cause, that about the shore of the strait of *Weigats*, so great abundance of floating wood is every where seen: and whereas in that strait near unto *Nova Zembla*, it is so extreme cold, it is no marvel, if in regard of the narrowness of the strait, so huge heaps of ice are gathered and frozen together, that in the end they grow to sixty or at least to fifty fathoms thickness: says the Description of the countries of *Siberia*, *Samojeda*, &c. extant in *Purchas*’s third part of his *Pilgrim*. Lib. 3. Chap. 7.

‘ is but one seventh part of ice above water, then the height of that piece of ice, which I observed, was one hundred and forty fathoms, or one thousand six hundred and eighty foot from the top to the bottom. This proportion I know doth hold in much ice; but whether it do so in all, I know not.’

THUS far of the height and depth of single pieces of ice: as for the other dimensions (the length and breadth) I remember not, that I have read of any, that had the curiosity to measure the extent of any of them, excepting Captain *James*; whose ship being once arrested between some flat and extraordinary large pieces of ice, he and his men went out to walk upon them, and he took the pains to measure some of the pieces, which he says he found to be 1000 of his paces long, pag. 17. And probably among so many mountains and islands of ice, there would have been found some intire pieces, of a greater extent than even these, if men had had the curiosity to measure them.

HITHERTO we have treated of the bigness of single pieces of ice; we will now proceed to say something of the dimensions of the aggregates of many of them, among which having elected four or five as the principal I remember myself to have yet met with, I presume it will be sufficient to subjoin them only.

‘ ABOUT ten of the clock we met with a mighty bank of ice, being, by supposition, seven or eight leagues, or twenty-four miles long,’ says that experienced English pilot *James Hall*, in his voyage of *Denmark* for the discovery of *Greenland*.

ANOTHER of our English navigators mentions, that even in *June*, ‘ all the sea (wherein he was endeavouring to sail) as far as he could see from the top of a high hill, was covered with ice; saving that, within a quarter of a mile of the shore, it was clear round about once in a tide.’ By which last clause, it seems, that this vast extent of ice was either one entire floating island, or at least a vast bank or rand (as some seamen term it) of ice.

BUT the strangest account of banks of ice, that I have yet met with in any sober author, is, that which is mentioned by the learned French hydrographer, *Fournier*; who relates, that in the year 1635, the French fleet sailing to *Canada*, met with several pieces of ice, as high as steeples, and particularly one, whether piece or bank of ice (for the French word *glace* may signify either) which they were troubled to coast along for above forty leagues. If this be the same story, (as one may suspect it to be, by the circumstances of the place, and fleet) there is a great mistake in another place, where our author speaks of the vastness of the ice: but if it be another story, as some other differing circumstances argue, the French, it seems, met with ice far more stupendous, than even that already mentioned. For, (says our author) in the sea, which washes *Canada*, there is often seen in the month of *August*, to pass by, ices much bigger than ships. In the year 1635, the French fleet sailing there, coasted along, for three days and three nights, one, that was above 80 leagues long, flat in some places like vast champions, and high in other like frightful hills. The latter part of which passage may confirm what we formerly delivered in another section, concerning the unequal compagination of icy islands.

To what has been said touching the extent, and other dimensions of floating, or at least loose pieces of ice, it will be fit to add something of the extent of ice, coherent to one or both of those shores, that bound the water, whose upper part is congealed. And in the first place, we shall, out of many instances to our present purpose, that might be borrowed from the writings of *Olaus Magnus*, select this one memorable one, that shall serve for all: *Neque minori bellandi impetu* (says he) *Sueci*

Hydrographie du P.
G. Fournier, liv. 9.
cap. 29.
compared with the
12th chapter of the
same book.

Olaus Mag.
lib. 3. cap.
2. pag.
334.

ac Gotbi super aperta glacie, quam in ipsa solidissima terra configunt; imo, ut prius dictum est, ubi antea æstivo tempore acerrima commissa sunt bella navalia, eisdem in locis glacie concreta, aciebus militari modo instructis, bombardis ordinatis, habentur horrendi confictus. Adeo solida glacies est in equestribus turmis sufferendis, ampliter vel stricte collocatis. I pretermitt then, what he elsewhere relates of the voyages and wars made in winter by the Northern nations. They, that have lived in those countries, relate as things most known and familiar, (what has been confirmed to me by more than one unsuspected eye-witness) the long journeys, that are commonly taken upon the icy bridges, or rather plains, by travellers, with all their carriages, to very distant places. And that, which may bring credit to these strange relations, by shewing, that no less unlikely ones are sometimes true, is, what all Europe knows, that within these three years the whole Swedish army, led on by their king, marched over the sea to the island of Zeeland, where Copenhagen, the capital city of Denmark, stands*. But it may seem much more strange, which I will therefore add, that as in the North countries frequently, so sometimes even in the warmer regions of the East, the sea itself has, by the cold, been congealed to a prodigious breadth. *Insolitum est, (faith Bartholinus) quod refert Constantinus Manasses in Annalibus accidisse, Theophilo imperante, ut hyems sæva mare cogeret in glaciem ad profunditatem sanè immensam, humidumque illud elementum, lapidis ad duritiem, fluxione prorsus ademptâ, redigeret.* And Michael Glycas relates, 'That in the year 775, the winter was so sharp in the East, that along the coast, the sea (he means the Mediterranean) was frozen for 50 leagues, and the ice was compacted as into a rock, 30 cubits deep; so strange a quantity of snow likewise falling, that it was raised to the height of 30 cubits above the ice.' Which likewise agrees very well with what we formerly noted, touching the possible increase of the height of some pieces of ice by the falling of the snow upon them.

Barthol. de
nivis usu
cap. 6.

Glycas
apud Four-
nier, liv.
9. cap. 19.

IV. It remains now, that we subjoin a few promiscuous observations concerning ice, that are not so readily deducible to the three foregoing heads.

AND we shall begin with what was taken notice of by the Dutch in their *Nova Zembla* voyage, where relating, how they fastened their ships to a great piece of ice, to shelter themselves from the stormy winds; 'There (add they) we went upon the ice, and wondered much thereat, it was such manner of ice: for on the top it was full of earth, and there was found about forty eggs; and it was not like other ice, for it was of a perfect azure colour, like to the skies, whereby there grew a great contention of words amongst our men, some saying, that it was ice, others that it was frozen land; for it lay unreasonably high above the water, it was at least eighteen fathom under the water, close to the ground, and ten fathom above the water.'

THE like blue colour in rocky pieces of ice, I remember I have somewhere found, to have been taken notice of by a modern † navigator; or whether the words of *Virgil*, concerning the frigid zone, *Cerulea glacie concreta, atque imbribus atris*, belong to this subject, I leave others to consider, nor shall I stay to examine, whether this blueness, that has been observed in ice, be always an inherent or permanent colour, or sometimes one of those, that are styled emphatical.

* — Sæpe aliàs & his annis fatalibus tam profunde congelavit (marina aqua) ut non tantum plaustrea, sed integrum exercitum ad aliquot milliaria Germanica secure vexerit, &c. Inquit T. Barthol. de nivis usu, pag. 43.

† In the evening we were inclosed amongst great pieces (of ice) as high as our poop, and some of the sharp blue corners of them did reach quite under us. Captain James, page 6.

Olaus, lib.
1. cap. 14.

It is very considerable, if it be true, what is related by *Olaus Magnus*, concerning the degenerating (if I may so speak) of ice from its wonted hardness in the spring of the year. For in the same chapter, where he gives us the lately transcribed account of the strength of ice in those northern countries, after having interposed some other passages, he subjoins these words; *Liquescente tamen glacie ad principium Aprilis, nullus ejus spissitudini, minus fortitudini, nisi in aurora, ambulando confidit, quia solis diurno aspectu tam fragilis redditur, ut quæ equestres armatos paulo ante portaverat, vix hominem nunc sufferre possit inermem.*

THIS puts me in mind to add, that oftentimes in the writers of journeys and voyages, we meet with mention of great noises made by the breaking of ice; and in this very chapter our archbishop taking notice of the clefts, that some time happen in champions of ice, adds, ‘That when the ice chances thus to open, especially if it be in the night, the noise of it may be heard a far off, like the loud and horrid noise of thunder, and of earthquakes.’ And on this occasion may be subjoined a couple of passages extant in different places of the formerly mentioned *James Hall’s* voyages: the first is thus delivered; ‘When we met with a huge and high island of ice, we steering hard to board the same, and being shot a little to northwards of it, there fell from the top thereof some quantity of ice, which in the fall did make such a noise, as though it had been the report of five cannons.’ But the next passage is more directly pertinent to our present subject, and is couched in these words; ‘About twelve of the clock this night, it being still calm, we found our selves suddenly compassed round about with great islands of ice, which made such a hideous noise, as was most wonderful, so that by no means we could double the same to the westward: wherefore, &c.’

Of these kind of icy thunders (as some travellers call them) there are divers instances to be met with, mentioned in the several voyages of the Hollanders, and particularly in those to *Nova Zembla*: but many of those noises seem to be made by the dashing of the great pieces of ice against one another; but if it happens, when the ice (as sometimes it is said to do) seems to cleave, as it were, of its own accord; to us, that live in a temperate climate, it may be a matter of some dispute, whence these loud ruptures of ice may proceed. For *Olaus Magnus*, in the chapter above cited, does not improbably ascribe them to the warm exhalations, that in some places ascend out of the ground. And I remember, in favour of this opinion, that I once caused divers pieces of thick ice to be brought out of a cool place into a somewhat warm room, and listening, observed a noise to come from them, as if it had been produced by store of little cracks made in them; but somewhat or other prevented me from repeating the experiment, and satisfying my self about the conjecture. But having lately inquired of an intelligent Polander, that has travelled much upon these icy plains, he agreed with our author, and others, as to the frightful noises, that are produced by these cracks of ice, but affirmed, upon his own observation, (for that I particularly inquired after) that these great clefts were often made, not by thawing heat, but by excessive cold, and that he had taken notice of them in extremely sharp weather. Indeed we sometimes observe, that in very bitter frosts the frozen ground will cleave, as we elsewhere have occasion to take notice. But whether that be not a different case from this, or whether the Polonian gentleman were not mistaken, or whether both these mentioned accounts, of the cleaving of ice, may on different conjunctures of circumstances take place, we leave to farther inquiry.

THERE is a tradition concerning ice, about the famous *Vulcano Hecla*, in *Iceland*, which, though verily believed among the superstitious vulgar of those parts, is spoken of so slightly by *Bleskenius*, who being upon that coast, had the curiosity to sail pur-

posely

posely thither, that I think it not worth while to take any farther notice of it. But it were too tedious to set down in this section, (which the strangeness and variety of the theme has made so prolix already) the other things, that may be mentioned without impertinency concerning ice; and therefore we shall here desist from so laborious a task, as also omit the handling of snow and hail: for though they are reducible to ice, yet I shall at least suspend the treating of them, partly because *Bartholinus* and meteorologists have saved much of my labour, and partly for the reason newly intimated: so that we shall conclude this section, as soon as we have taken notice, that there is yet somewhat relating to ice, which, being in it self considerable, and whereof hitherto no experimental account appears to have been given, what we our selves have tried about it, may challenge to be treated of apart.

Olaus Magnus, lib. 11.
& Bleskenius in Purch. 1. 31.
c. 22.

T I T L E XVI.

Experiments and observations touching the duration of ice and snow, and the destroying of them by the air and several liquors.

IT may be an experiment, as well instructive as new, to determine, what liquor dissolves ice sooner than others; and in what proportion of quickness the solutions in the several liquors are made. For men have hitherto contented themselves to suspect in general, that there are other liquors potentially hot, wherein ice will sooner dissolve, than it will in water. But this opinion either being grounded upon no experience at all, or taken up upon the sight of what happens to pieces of ice, which no care was taken to reduce to the same bulk and figure, no more than to measure attentively how long one outlasted the other; we thought fit to try, if we could not bring this matter to experiment, and make a determination in it, though not exactly true, yet less remote from exactness, than had been yet, for aught I know, so much as attempted.

2. In order to this, we procured some bullet moulds, and having first carefully stopped the little crevice, that is wont to remain betwixt the two halves of the mould, with a good close cement, we afterwards filled them with water, and carefully closed up the orifice of the hole, at which the water was poured in; and then setting the mould to freeze in ice and salt, we found it difficult enough to keep the water (more or less of it) from running away through some unperceived passage, before the cold could have time by congealing it to arrest it. But after a while, when we had thus made a bullet of ice, we found it a new and greater difficulty to get it whole out of the moulds, without warming them; for by that way we could indeed loosen the ice, but then we could not avoid thawing it too, and that most times not uniformly: wherefore we tried by greasing the inside of the moulds to keep the ice from sticking so close to them, (notwithstanding the distension the water suffered by its being frozen) but that we might pick out the bullet entire; and this succeeding well enough, we hoped by this way to obtain our end, which was to have a competent number of pieces of ice of equal bulk, and of the same figure, to be put at once to thaw in several liquors. But we could by no means procure moulds, which had any number of distinct cells of the same bigness, those long pairs of moulds, that were to be met with in shops, having their distinct cells generally made on purpose of very different bignesses, which rendered them altogether useless for our design. Wherefore we were fain, for want of an exacter way, to take a glass pipe of the most even and cylindrical that we had, and of a bore capable to admit a big man's little finger. This glass being stoppt at one end, and kept open at the other, was filled to the height of about half a foot or more of fair water; and ice and salt being heaped up about it, that the cold

cold might reach as far as the water did, it was quickly frozen. In the mean while I had caused several wide-mouthed glasses to be brought into my chamber (wherein, by reason of some indisposition, that hindered me from going abroad, I kept some fire) and having poured several liquors into these glasses, which had been placed all on a row, we suffered them to rest there a while, that the ambient air might have time to reduce them, as far as it could, to its temper, and consequently to the same temper as to heat and cold: and then, with the warmth of one hand, the included ice being loosened from the glass, as it was taken out, and a ruler divided into inches and eighths, being laid alongst it, with a knife a little warmed, the ice was soon, and yet not carelessly, divided into several small cylinders of three quarters of an inch apiece; and these cylinders thus reduced to as sensible an equality as we could, were nimbly and carefully put into the several liquors hereafter to be mentioned. And whilst we our selves watched very attentively, till each of these icy cylinders was quite, and yet but just dissolved, we caused others to keep time by the help of a pendulum, whose vibrations were each a second minute, (or 60th part of a common minute, whereof 60 go to make an hour) and it was easy for those we appointed, to watch the vibrations of the pendulum, notwithstanding the quickness of its motion, because it was fitted to a little instrument purposely contrived for such nice observations, wherein a long index moving upon a divided dial-plate did very manifestly point out the number of the diadromes made by the pendulum.

3. This experiment was afterwards repeated twice with cylinders of ice, each of them an inch long; and though the successies of these trials were various enough, yet we shall subjoin both the former, (as being made with more advantage, than the last) that the more light may be gathered from them, and that at least we may discover, how difficult it is to make such experiments in this matter, as that all the nice circumstances of them may safely be relied on.

I. Trial.

1. OIL of vitriol, where a cylinder of ice, of an inch long, being put into, lasted five minutes.
2. SPIRIT of wine, (in which the ice sunk) lasted 12 minutes.
3. AQUA FORTIS lasted $12\frac{1}{2}$ minutes.
4. WATER lasted 12 minutes.
5. OIL of turpentine lasted (not good) 44 minutes.
6. AIR lasted 64 minutes.

II. Trial.

1. IN oil of vitriol, where an inch of cylindrical ice lasted 3 minutes.
 2. IN spirit of wine, lasted 13 minutes.
 3. IN water, lasted 26 minutes.
 4. IN oil of turpentine, lasted 47 minutes.
 5. IN faller oil, lasted 52 minutes.
 6. IN the air, lasted 152 minutes.
4. We likewise thought it worth trying, whether there would be any difference, and how much difference there would be in the duration of pieces of ice of the same bulk and figure, some of them made of common water, and others of frozen wine, milk, oil, urine, and other spirituous liquor; these several pieces being exposed to be thawed in the same air, as other ambient liquor.

5. We

5. WE also tried, whether motion would impart a heat to ice, by nimbly rubbing a strong piece of ice upon a plate of ice; and though this seemed to hasten the dissolution in that part of the icy plate, where the attrition had been made, yet we were unwilling to determine the matter, till further and exacter trial have been made.

6. AND this brings into my mind an experiment, that has by some been thought very strange. The occasion I remember was, that I received the last winter the honour of a visit from a nobleman of great eminency and learning, who chancing to come in, while I was making some trials with ice, would needs know what I was doing with it; but the presence of a very fair lady, in whom *Hymen* had made him happy, and of some other company of that sex, that he brought along with him, inviting me to give him the answer, that I thought would be most suited and acceptable to his company, I merrily told him, that I was trying, how to heat a cold liquor with ice; and to satisfy him, that was no impossibility, I held out an open-mouthed glass, full of a certain liquor (which for some just reasons I do not describe, but do plainly teach it in an opportuner place) and desired them to feel, whether it were not actually cold. And when they were satisfied it was so, I chose among the pieces of ice, that lay by me, that I judged by the eye to be fit for my purpose, (for every piece was not so, for a reason I elsewhere shew) and throwing it into this liquor, it did not only in a trice vanish in it, but the lady, I was mentioning, seeing the liquor smoke, and advancing hastily to try, whether it were really warm, found it so hot, that she was quickly fain to let it alone, and had almost burnt her tender hand, with which she had, in spite of my dissuasion, taken hold of the glass, which her lord himself could scarce endure to hold in his. But this experiment, which for the main I have repeated before competent witnesses, though it be not impertinent to the *History of Cold*, yet I shall not build much upon it; because, how strange soever many have been pleased to think it, I shall elsewhere shew, that I made use of a certain unperceivable sleight, which, in my opinion, did as well, as the nature of the liquor and the texture of the ice, contribute to the suddenness and surprisingness of the effect.

7. BUT to return to the duration of the effects of cold, I think those much mistaken, who imagine, that the effects of cold do continually depend upon the actual presence and influence of the manifest efficient, as the light of the air depends upon the sun, or fire, or other luminous body, upon whose removal it immediately ceases. For when cold agents have actually brought a disposed subject to a state of congelation, though the manifest efficient cause cease from acting, or perhaps from being, the effect may yet continue. For in most cases, if a certain texture be once produced in a body, it is agreeable to the constancy of nature, that it persevere in that state, till it be forcibly put out of it, by some agent capable to overpower it. And though we usually see ice and snow, as it were of their own accord to melt away, when the frosty constitution of the air ceases; yet the cause of that may be not barely the cessation of frosty weather, but that those easily dissoluble bodies are exposed to the free air, which being heated by the sun-beams, and perhaps by calorifick exhalations from the earth, is furnished with an actual cause, upon whose account it destroys the texture of the ice and snow. But even here above ground, if snow be well compacted into great masses, in which, by reason of the closeness of the little icicles, but little air is allowed to get between them, I have seen such masses of snow last so long, not only in thawing, but in rainy weather, as to be wondered at; and if such snow (or ice) be kept in a place where it may be fenced from the sun, and other external enemies, though the place, it is lodged in, be not any thing near cold enough to produce ice, yet it will, as some trial hath taught me, preserve ice and snow for a very long time.

Appendix to the XVIth Title.

AN eminent instance to confirm what is delivered at the close of the foregoing section, is afforded us by the conservatories, wherein snow and ice are kept all the summer long. Of these I have seen in *Italy*, and elsewhere; but supposing I had the command of some Italian, and other books, wherein I should meet with the dimensions, and other circumstances, that belong to them, my finding my expectation disappointed by those books, makes me think it very well worth while to subjoin somewhat about things, that may give us opportunity of making a multitude of experiments about cold. And therefore meeting the other day (by good chance) with my ingenious friend Mr. *J. Evelyn*, his inquisitive travels, and his insight into the more polite kinds of knowledge, and particularly architecture, made me desire and expect of him that account of the Italian way of making conservatories of snow, that I had missed of in several authors; and having readily obtained my desire of him, I shall not injure so justly esteemed a style as his, to deliver his descriptions in any other words, than those ensuing ones, wherein I received it from him.

[THE snow-pits in *Italy*, &c. are sunk in the most solitary and cooled places, commonly at the foot of some mountain or elevated ground, which may best protect them from the meridional and occidental sun: 25 foot wide at the orifice, and about 50 in depth, is esteemed a competent proportion. And though this be excavated in a conical form, yet it is made flat at the bottom or point. The sides of the pit are so joiced, that boards may be nailed upon them very closely jointed. (His Majesty's at *Greenwich*, newly made on the side of the Castle-hill, is, as I remember, steened with brick, and hardly so wide at the mouth.) About a yard from the bottom is fixed a strong frame or tressel, upon which lies a kind of wooden grate; the top or cover is double thatched, with reed or straw, upon a copped frame or roof, in one of the sides whereof is a narrow door-case, hipped on like the top of a dormer, and thatched; and so it is compleat.

I have seen also the sides lined with reeds longways, instead of boarding or steening.

To conserve snow:

THEY lay clean straw upon the grate or wattle, so as to keep the snow from running through, whilst they beat it to a hard cake of an icy consistence, which is near one foot thick: upon this they make a layer of straw, and on that snow, beaten as before; and so continue a bed of straw, and a bed of snow, S. S. S. till the pit be full to the brim. Finally, they lay straw or reed (for I remember to have seen both) a competent thickness over all, and keep the door locked. This grate is contrived, that the snow melting by any accident in laying, or extraordinary season of weather, may drain away from the mass, and sink without stagnating upon it, which would accelerate the dissolution, and therefore the very bottom is but slightly steened. Those, who are most circumspect and curious, preserve a tall circle of shady trees about the pit, which may rather shade, than drip upon it.]

THUS far this learned gentleman's account of conservatories of snow. And on this occasion I might add what the Dutch in their *Nova Zembla* voyage relate, namely, that 'the three and twentieth of *June*, though it were fair sun-shiny weather, yet 'the heat was not so strong, as to melt the snow, to afford them water to drink; 'and that in spite of their being reduced to put snow in their mouths, to melt it 'down into their throats, they were compelled to endure great thirst.' But because it was in so cold a climate, that this duration of the snow was observed, I shall take notice, that in the *Alps*, and other high mountains, even of warmer climates, though

the snow doth partly melt towards the end of summer; yet in some places, where the reflection of the sun-beams is less considerable, the tops will even then remain covered with snow, as we among many others have in those countries observed. And for further confirmation of the doctrine delivered at the end of this 16th title, I shall subjoin a passage, which having unexpectedly met with in an unlikely place of Captain *James's* voyage, I think not fit to leave unmentioned here; not only because it is the sole artificial observation, that I yet met with, concerning the lasting of ice, and so may recommend to us the ingenuity of an author, whose testimony we somewhat frequently make use of; but because the observation is in itself remarkable, and notwithstanding the difference of places may serve for the purpose we alledge it: our navigator's words are these; *page* 101. 'I have in *July*, and in the beginning of *August*, taken some of the ice into the ship, and cut it square two foot, and put it into the boat, where the sun did shine on it with a very strong reflex about it. And notwithstanding the warmth of the ship (for we kept a good fire) and our breathings, and motions, it would not melt in eight or ten days.' And it is also considerable to our present purpose, what the same author elsewhere has about the durableness of the congelation of the ground not yet thawed at the beginning of *June*. 'For the ground (says he, *pag.* 65.) was yet frozen; and thus much we found by experience in the burying of our men, in setting up the king's standard towards the latter end of *June*, and by our well at our coming away in the beginning of *July*; at which time upon the land, for some other reasons, it was very hot weather.'

T I T L E XVII.

Considerations and experiments touching the Primum Frigidum.

1. **T**HE dispute, which is the *Primum Frigidum*, is very well known among naturalists: some contending for the earth, others for the water, others for the air, and some of the moderns for nitre: but all seeming to agree, that there is some body or other, that is of its own nature supremely cold, and by participation of which, all other cold bodies obtain that quality.

2. **B**UT for my part, I think, that, before men had so hotly disputed, which is the *Primum Frigidum*, they would have done well to inquire, whether there be any such thing or no, (in the sense newly expressed.) For though I make some scruple, resolutely to contradict such several sects of philosophers, as agree in taking it for granted, yet I think it may be not irrationally questioned, and that upon two or three accounts.

3. **F**OR (first) it is disputable enough, as we shall hereafter see, whether cold be (as they speak) a positive quality, or a bare privation of heat: and till this question be determined, it will be somewhat improper to wrangle solicitously, which may be the *Primum Frigidum*. For if a body's being cold, signify no more than its not having its sensible parts so much agitated, as those of our sensories, by which we are wont to judge of tactile qualities; there will be no cause to bring in a *Primum Frigidum*, upon whose account particular bodies must be cold: since to make this or that body so, it suffices, that the sun or the fire, or some other agent, whatever it were, that agitated more vehemently its parts before, does now either cease to agitate them, or agitate them but very remissly, so that, till it be determined, whether cold be a positive quality, or but a privative; it will be needless to contend, what particular body ought to be esteemed the *Primum Frigidum* (in the sense above specified.)

* In the
Sceptical
Chymist.

The Dia-
logues about
Heat and
Flame.

4. SECONDLY, though it be taken for granted, not only by the schools, but by their adversaries the chymists, that heat and moisture, dryness and gravity, and I know not how many other qualities, must have each of them a *πρῶτον δεκτικόν*, or a principal subject to reside in, upon whose account, and by participation of which, that quality belongs to the other bodies, wherein it is to be met with; though this be so, I say, yet we have * elsewhere fully enough manifested, that this fundamental notion, upon which much of the doctrine of qualities is both by Aristotelians, and vulgar chymists, superstructed, is but an unwarrantable conceit, and therefore not sufficient for a wary naturalist to build the notice of a *Primum Frigidum* upon; there being indeed many qualities, as gravity, and figure, and motion, and colour, and sound, &c. of which no true and genuine *πρῶτον δεκτικόν* can (for aught I could ever yet discover) be assigned. And because heat and cold are looked upon as diametrically opposite qualities, we may consider, that it will be very hard to shew, that there is a *πρῶτον δεκτικόν* of heat; since stones, and metals, and plants, and animals, and (very few excepted) all consistent bodies, we are conversant with, may by motion be brought to heat; which to attribute to the participation of some portion or other of the imaginary element of fire, is not only precarious (being affirmed by many, and proved by none) but erroneous, or at least needless, as we have more at large declared in other papers.

5. A THIRD thing, that induces me to question, whether there be a *Primum Frigidum*, is, that among those bodies, that the chiefest sects of philosophers, whether ancient or modern, have pitched upon, there is not any, that seems clearly to deserve the title of *Primum Frigidum*. But to make this appear, we must distinctly (though as briefly as our design will permit) consider those four several bodies, which we have (at the beginning of this section) taken notice of, to stand in competition, in the opinions of philosophers, for the title of *Primum Frigidum*.

6. FIRST then, *Plutarch* and others contend, that it is the earth; but to omit other arguments, we see, that the earth is frozen not by its own cold, but by its vicinity to the air, as may be argued by this, *viz.* that the congealing cold, even in the midst of winter, affects but the surface of the earth, where it borders on the air, and seldom pierces above a few feet, or, at most, yards, beneath that part, wherein the earth is exposed, and immediately contiguous, to the air; as may appear by what we have formerly delivered concerning the small depth, to which frosts reach in the ground. And therefore if the earth be protected from the air (though by so cold a body as water) it may be kept unfrozen all the winter long; as may be gathered from that remarkable practice in the great salt-marshes of the French islands of *Xaintonge*, where, as a diligent writer of that country, very well versed in the making of the French salt, informs us, when once the season of coagulating salt by the heat of the sun is quite past, the owners are careful, by opening certain sluices, to overflow all the banks, and dams, that make and divide the salt-ponds, and serve for the workmen to pass to and fro: for (says my author in his own language) if they left those marshes (or salt-works) uncovered, the frost would make such havock amongst them, that it would be necessary to make them up again every year; but by means of the water they are preserved (or kept in repair) from year to year. Which practice I the rather mention, because the hint, it affords, as it is considerable to our present purpose, so it may on some occasions be applicable to practices useful to human society.

7. BESIDES, the earth being (according to those we reason with) the coldest, heaviest, and solidest of elements, it is not so probable, as to excuse them from need of proving it, that those excessively cold agents, that freeze the clouds into snow and hail,

hail, should be terrene exhalations carried up to the middle region of the air; especially since it must be done by agents, either hard to be guessed at, or considerably hot. And it is not easy to give a reason, why, if elementary corpuscles, steaming from the earth, have such a congealing cold, where they are disunited, and but interspersed among the particles of air; the mass of the earth it self, whence those exhalations are supposed to proceed, should not be able also to congeal water, since the terrestrial corpuscles being more thick set, and united in a clod of earth, than in an equal portion of the atmosphere, it seems, that where the frigorifick matter is more dense, the cold should be more vehement; as philosophers observe, that heat is more intense in a glowing bar of iron, than an equal portion of the flame of kindled straw.

8. BUT (not to repeat what we formerly mentioned about cold's being a privation) there is another argument against the earth's being the *Primum Frigidum*; and that is taken from the subterranean fires, which breaking forth in many places of the earth, as in *Ætna*, *Vesuvius*, *Hecla*, the *Pico of Teneriffe*, &c. seem to argue a subterranean fire; upon whose existence not only many chymists build great matters, but even divers philosophers have adopted it, as to employ it as one argument of the earth's being naturally neither hot nor cold. The mention of this subterranean fire brings into my mind some things, that I have met with amongst good, though not classick, authors, and amongst men, that have been either diggers of, or conversant in, mines, not improper to be here taken notice of. For though I do not now intend to declare my opinion about the central fire, either of the chymists or Cartesians, and though the examples newly mentioned, and such other, seem to me but very inconsiderable, in reference to the whole earth; yet it is observable to our present purpose, that there should be so much subterranean heat or warmth, at least generally to be met with. For even where there appear no manifest signs of subterranean fires, I have known those, that were wont to go to the bottom of deep mines, complain, that a very little exercise would put them into a great sweat; and a learned and experienced French doctor, that hath written in his own language, of stones and jewels, affirms, that in such mines the subterranean vapours and exhalations, are visibly so abundant, and likewise so hot, that the mine-men are constrained (which a person I spoke with affirmed to me, touching himself) to work in their shirts, by reason of the great heat they there felt. And though I would have been glad to know, whether those deep places would have appeared as hot, when judged of by a sealed weather-glass, as they did to the mine-mens sensories, because of some little doubt I harboured, whether much of that copious sweating, and seeming heat, might not proceed from the thickness of the dampish air, and its unsuitness for respiration; yet, because a virtuoso, that had a lead-mine of his own, in which he wrought himself for curiosity, answered me, that he was not wont to find any difficulty of breathing in the place, where he was so apt to sweat; and since I find not, that others have complained of having their respiration incommodated in such places, unless by accidental damps, my scruple was much abated; and the rather, because the author lately mentioned expressly affirms, that the sudorifick heat (if I may so speak) is to be found in the bowels of the earth, as well in summer as in winter, which prevents the ascribing of it to *Antiperistasis*. And in other places than mines it is generally observed, that wells and springs freeze not, if the place whence the water is drawn be very deep; but, as we have observed elsewhere, that it oft comes up smoking, and, as it were, reeking; which argues, that at the least the earth, wherein it was harboured, or through which it passed, was, if not warm, free from such a degree of cold, as might be expected in the earth, if it were the *Primum Frigidum*. Nor can it be reasonably pretended, that the

De Claves
au second
Livre des
pierres &
pierreries,
cap. 2.

Ibid.

Monfieur de
Claves,
liv. II.
cap. 8.

subterranean heat comes from the beams of the sun, since learned men have observed, that those heat not the earth above six or seven foot deep even in Southern countries; and though we should allow them to pierce three times as far, yet that would not be considerable to the depth of the mines above-mentioned; and if the lower part of the earth were of its own nature cold, and received the heat it discloses only from the sun and stars, the deeper men dig, the lesser of heat and fleams they would meet with; whereas the above-cited French mineralist affirms, that the lower they go, the more vapours, exhalations, and heat they find.

9. BUT because this learned man delivers this circumstance in a dogmatical, rather than an historical way, I will add somewhat out of a relation (whence I have * elsewhere taken other particulars) made by a French physician likewise, that had the curiosity to descend himself into the deep mines of *Hungary*; some of which, that he went down into, may be collected by his narrative, to have three or four hundred fathom, that is, eighteen or twenty-four hundred foot of perpendicular depth. This author then relates, that after he had descended about 80, or 100 fathoms, he came into a very warm region of the earth, which lasted to the bottom of the mine, and is so hot both winter and summer, that the labourers are wont to work in it without their clothes, and he was scarce able to indure the heat of it, although the external air were very hot, the weather being very fair, and the month *July*†. He adds, that he having demanded of the overseer of the mine, whence this heat came, he was answered to that and several other questions, that it came from the lower parts of the earth; that wherever they dig the ground, after they are come to such a depth (which he elsewhere mentions to be about 80 or 100 fathom) they feel no more any cold, but a perpetual heat, how deep soever they dig, (‡ yet without observing, that after they are once got into that warm region, they find the heat sensibly increase, the nearer they approach to the centre of the earth, unless by accident they happen to dig through veins of hotter minerals). And these answers (subjoins my author) I received not in one mine alone, or from a single overseer, but in all the mines, and from all the masters of them; so that if these were not mistaken, we may safely conclude, that as far as experience can inform us, the body of the earth in its lowermost parts, where it is presumed to be coldest, is every where, and that considerably, hot. I said, *if these mine-men were not mistaken*,§ because having been in the bottom of some mines myself, though I find it acknowledged, that it is still warm in the bottom of deep ones; yet I confess, I somewhat suspect, by what I have observed, that this degree of heat, which our French physician found in the Hungarian mines, might be rather in great part from the peculiar nature of those places, or of the minerals generated there, than barely (as he and those, that informed him, suppose) from the greatness of their depth beneath the surface of the earth: for I know several mixtures, besides those that are common, of bodies neither of them actually hot, which

* In the discourses about *Antiperistasis*, the following passages are taken out of a small narrative, consisting of about two sheets of paper of *Jo. Baptista Morinus*, published in the year 1619, and entitled, *Relatio de Locis Subterraneis*, annexed to a discourse (too much built on. Astrological and Aristotelian grounds) of the threefold region, that he conceives to be as well in the earth as in the air.

† Unde calor ille procederet petii à præfecto? Respondit, ex partibus inferioribus, inferius enim perpetuo calet. Quod responsum magis adhuc miratus, quævis an res ita sese haberet in fodinis omnibus? Respondit ita se habere in omnibus, saltem profundis, ut post profundum terræ frigidæ tractum, in locum calidum descendatur. Et quod, ubicunque terra foditur post similem profunditatem, nullum amplius sentitur frigus, sed semper calor, quantumcunque profundè fodiatur.

‡ Percussatus sum, an quo magis acceditur ad terræ centrum, calor ille major perciperetur? Respondit, id nunquam fuisse animadversum, nisi interdum dum fodiendo occurrebant venæ calidorum mineralium. ———— Hæc responsa non in unicâ fodinâ, sed ab unico præfecto accepi; sed, &c.

will produce a considerable degree of heat. And very credible eye-witnesses affirm, that in some parts of *England* they dig up a good store of a kind of mineral, which is thought to be of a vitriolate nature, which, by the bare addition of common water, will grow hot, almost to ignition. So that the Hungarian mines being deep, as appears by our author's narrative, being not destitute of water enough to make a subterranean spring in the mine itself, besides what water may plentifully ascend in the forms of vapours, and moisten the ore, it may be suspected, that either the water, or some appropriated mineral spirit or juice (of which the bowels of the earth may contain divers, that we know nothing of) may produce, together with the mineral, a warm steam, which, for want of sufficient vent in those narrow, and close places, may heat them considerably. Which conjecture may be countenanced by these three circumstances, that I took notice of in our author's narrative; one, that the smoke, that copiously ascended out of the mine by the perpendicular groove, was not barely hot, but consisted of stinking exhalations, which were so saline, and fretting, as oftentimes to corrode and spoil both the wooden ladders or stairs, and the iron instruments of the diggers. The other, that the overseers themselves of the mines told *Morinus* (as we lately saw) that they in some places met with veins of hot minerals, which made it hotter than the bare vicinity of those places to the centre of the earth would have done. And lastly ||, as our author was descending into the golden mine at *Cremnitz*, he found in one place, the heat to increase as he descended more and more, (which seems not to agree with a passage we lately mentioned out of him) and to exceed any he had met with in any other mine; and afterwards the overseer bringing him into a room, that abounded with smaragdine vitriol, (the mineral, whence this heat proceeded) though the room were spacious, he found there, besides a sharp spirit very offensive to his throat, so troublesome a heat, that he was ready to faint away with sweating, and very much wondered how the diggers were able to work there. And elsewhere the author himself notes, that such hot mines of vitriol, or sulphur, may be found even in the first region of the earth, (as he calls that, which is somewhat near the surface, which he thinks fit to name the *cold region*) and within a large sphere of activity make it perpetually hot. But this, as I was intimating, I mention but as a suspicion, or a conjecture; and notwithstanding that the degree of heat may be much increased in these mines, by the concurrence of accidental causes, in case the conjecture be admitted; yet the frequency of a sensible degree of heat in very deep places does very little favour their opinion, that will allow the earth to have no other heat but what it receives from the sun-beams, or by the manifest fire of burning hills, as *Ætna* and *Vesuvius*. And if it should be objected, that this subterranean heat is adventitious to the earth, which is supremely cold of its own nature; *Gassendus* might reply, that it is as likely, that the coldness of it near the superficies may be adventitious too, and that it appears at least as manifestly, that the one proceeds from the contiguous air, as it does, that the other proceeds from some included fire. And if I misremember not, he hath this consideration, that it is somewhat strange, that nature should have intended the earth for its *Summum Frigidum*, and yet that a greater part (and for aught we know the greatest) should be constantly kept warm, either by the sun, as under the torrid zone, or by the subterranean fires. But the objection mentioned against *Gassendus* opposes but one of the arguments we have alledged against the earth's being the *Primum Frigidum*, they mean not the elementary earth, but some body

|| Cum descendendo calorem illam magis ac magis augeri sentirem; hujus rationem petii à præfecto, quod in nullâ adhuc ordinâ similem caloris intensiorem percipissem. Respondit, mineram vitrioli paulo inferius existere, quæ calorem multiplicaret.

that is mingled with it; I shall desire to know, which it is they mean, of the many other bodies, that make up the terrestrial globe, that we may examine what right it has to that title. And in the mean time I shall conclude against them, that the earth it self has none, since they grant a colder body than it, and such a one as the earth must be beholden to, for the greatest degrees of coldness it chances to possess.

11. BUT though, I presume, enough has been said to make it appear unlikely, that the earth should be the *Primum Frigidum*, yet I must in this dissent from the learned *Gassendus*, that he thinks the earth, not only not to be the *Primum Frigidum*, but not to be naturally cold any more than hot. For the insensible parts of the earth, like those of other firm bodies, being heavy, and perhaps gross, and either having no constant motion at all, or at least a far more remiss agitation, than that of our sensories; it seems to follow, that the earth must seem cold to us, unless it be, by the communicated heat, or motion of some extrinseck agent, put into a degree of agitation, that belongs not to its own nature. And for the like reason I think it not improbable, that pure earth should in its own nature be colder, than either pure water, or pure air; since the earth being a consistent body, its component particles are at rest among themselves, or at least moved with an almost infinite slowness; whereas water and air being fluids, their component particles must be in a restless and various motion, and consequently be less remote from heat, which is a state, wherein the various agitation of the minute particles is more vehement.

12. AND if those, that plead for the earth, had declared, that they meant not the pure or elementary earth, but that part of the terrestrial globe, that is distinct from the sea, and other waters, that make it up, and would have earth in that sense not to be the *Primum Frigidum*, but only the *Summum Frigidum*, perhaps they might have a better plea for their opinion, than they can urge for theirs, who contend for the water or the air; especially, if, to countenance their opinion, this memorable observation be added, which I have met with among those navigators, that have had the greatest experience of the frigid zone; for the Dutch, that sailed thrice to *Nova Zembla*, and once wintered there, * affirm in their first voyage, that the highest degrees of cold are not to be met with in the main sea, where yet men are most exposed to the operations of the air, and of the water, but either upon the land or near it. That accurate geometrician and hydrographer *Fournier* tells us, that in 1595, the Hollanders being intercepted by icy shoals in the strait of *Weigats*, and meeting with certain Muscovites, demanded of them, whether those seas were always frozen; and were answered, that neither the northern sea, nor that of *Tartary* did ever freeze; and that it was only that strait, with the sea contiguous to the shores of some bays and gulphs, that were frozen. And our judicious author not only adds, that in effect all those, that sail into those parts, relate, that all those lumps of ice are such as have been loosened, and severed from the islands, and the rivers of the *Samojeds* and *Tartars*, but adventures to affirm in general terms, that it is certain, the main seas never freeze, and that it is but the confines, and shores of some of them, that are frozen.

13. THAT the water is the *Primum Frigidum*, the opinion of *Aristotle* has made it to be that of the schools, and of the generality of philosophers. But I can as little

* It was not the sea, nor the nearness unto the pole, but the ice about the land, that lett and hindered us (as I said before); for that as soon as we made from the land, and put more into the sea, although it was much farther northward, presently we felt more warmth, and in that opinion our pilot *William Barents* died, who notwithstanding the fearful and intolerable cold that he indured, yet he was not discouraged, but offered to lay wagers with divers of us, that by God's help he would bring that pretended voyage to an end, if he held his course north-east from the north-cape. *Gerat de Veer in Purchas*, p. 474.

acquiesce in this opinion, as in the former, not finding it agreeable to what experience teaches us.

14. For not to mention, that it would be very difficult to prove, that divers very cold bodies, as gold, and silver, and crystal, and several other fusible stones have in them any water at all, to which their coldness may with any degree of probability be ascribed; nor to urge the arguments, that some modern contenders for the supreme coldness of the air are wont to imploy; not (I say) to insist on such things, I shall content my self to make use of this obvious $\phiαινόμενον$ of cold, that in rivers, ponds, and other receptacles of water, the congelation begins at the top, where the liquor is exposed to the immediate contact of the air; which sufficiently argues, that the air is colder than the water, since it is able not only sensibly to refrigerate it, but to deprive it of its fluidity, and congeal it into ice: whereas if the water it self were the *Primum Frigidum*, either it ought to be, at least as to the major part of it, always congealed, or we may justly demand a reason, why, when it does freeze, the glaciation should not begin in the middle, or at the bottom, as soon as at the top, if not sooner. And our arguments against the precedency of the water in point of coldness may be strengthened by this, that frosts are wont to be hardest, when the air is very clear, and freest from aqueous vapours; whereas in rainy weather, wherein such vapours most abound, the cold is wont to be far more remiss. To which we may add, what we lately delivered from the observation of navigators, that even in the frigid zone the main sea, where yet the water is in the greatest mass, and so most likely, as well as advantaged to disclose its nature, never freezes, though the straits, and bays, and gulphs be frozen over; which argues, that the greatest degrees of cold are rather to be assigned to the air, or to the earth, than to the water, which by the practice formerly mentioned of the masters of the French salt-marshes appears to be (when it is of a considerable depth) fitter to preserve bodies from congelation, than to congeal them. Which instance I the rather repeat, because it seems to argue, that the water is not so much as disposed to receive any very intense degree of cold at a remote distance from the air. For though navigators tell us of exceeding thick pieces of ice, yet, as we have already elsewhere noted, we are not bound to believe, that the congealing cold has pierced any thing near so much as that thickness amounts to, from the superficies of the sea directly downwards: for though it were no great matter, if it did, in comparison of that depth of the sea, which, though the water be naturally cold, the sharpest air is unable to congeal; yet we have elsewhere proved, that those thick masses of ice are not solid and intire pieces, but rather heaps of many flakes, and other fragments of ice, which running upon one another, or sliding under one another, are by the congelation of the intercepted water (and perchance half thawed snow) as it were, cemented together into mishapen unwieldy masses: which conjecture agrees very well with that observation of the ingenious captain *James*, which he delivers in these words:

‘ It seldom rains after the middle of *September*, but snows; and that snow will not melt on the lands, nor sands: at low water, when it snows (which it doth very often) the sands are all covered over with it, which the half-tide carries officiously (twice in twenty-four hours) into the great bay, which is the common rendezvous of it. Every low water, are the sands left clear, to gather more to the increase of it. Thus doth it daily gather in this manner till the latter end of *October*, and by that time hath it brought the sea to that coldness, that as it snows, the snow will lie upon the water in flakes, without changing its colour, but with the wind is wrought together, and as the winter goes forward, it begins to freeze on the surface of it, two or three inches, or more in one night; which being carried with the half tide,

‘ tide, meets with some obstacle (as it soon doth) and then it crumples, and so runs upon it self, that in few hours it will be five or six foot thick; the half-tide still flowing, carries it so fast away, that by *December* it is grown to an infinite multiplication of ice.’ Thus far this navigator; to which I shall add another passage out of one of his countrymen, (Mr. *Hudson*, famous for the northern discoveries, that bear his name) by which, added to what has been elsewhere delivered to the same purpose, we may be invited to believe, that the vast hills and islands of ice, that are to be met with about the straits of *Weigats*, and elsewhere, are not generated of the sea itself. ‘ It’s no marvel (says he, *Purchas*, lib. 3. cap. 15. p. 579.) that there is so much ice in the sea towards the pole, so many founts and rivers being in the lands of *Nova Zembla*, and *Newland* to ingender it, besides the coasts of *Pecora*, *Russia*, *Greenland*, with *Lappia*, as by proof I find by my travel in those parts.’

15. BUT for all this, I think not fit, as does the ingenious *Gassendus*, and some others, to make the water indifferent, as to heat and cold. For, as I formerly noted concerning the earth, so I must now represent touching the water, that, setting aside the heat of the sun, which is but adventitious, where it does operate, and which leaves many vast portions of that element, which it does not constantly reach, the insensible parts of water are much less agitated, than those of our sensories temperately disposed, and consequently may in regard of us be judged cold. For though water being a liquor, I readily allow it a various motion of its component corpuscles, (that being requisite to make a body fluid) yet such an agitation, which is sufficient for fluidity, may be, and often is, far more remiss, than that of the spirits, blood, and other liquors of so hot a sanguineous animal as man; as we see, that urine, though after it has been long emitted, it continues a fluid body, yet its parts are far less agitated, than they were, when it came hot, and reeking out of the bladder.

16. AND upon this occasion, I shall add, what by inquiry I have learned, that (except the parts somewhat near the superficies of the water, which the heat of the sun, or the warmth of the neighbouring lower region of the air may give some warmth to) the whole body of the sea is very cold: for being very well acquainted with one, that for some time got a livelihood by going down into the bottom of the sea, to fetch up what could be recovered out of shipwreckt vessels, I purposely inquired of him, what cold he felt under water; and he more than once told me, that though near the top of the water the cold were very moderate, yet when he was necessitated to descend a great depth, he found it so great, that he could not very long support it. And particularly he told me, that having occasion to descend about twelve or fourteen fathom deep (which is nothing in comparison of the depth of many seas) to fasten ropes to the ordnance of a great ship, that was some years since cast away, near the coast of one of the northern countries; though he was not incommoded in point of respiration, and though he felt no other inconveniencies, that might dissuade his tarrying longer, yet the cold was so great, and troublesome, that he was not able to endure it above two or three hours, but was constrained to remount to a milder, as well as higher region. I wished several times he had had with him a weather glass (for ordinary thermometers would on that occasion have been unserviceable) to prevent some little doubt, that might be made, whether the intense cold he felt might not be only and chiefly in reference to his body, which might be so altered, and disposed by this new briny ambient, as to make such a disturbance in the course or texture of his blood, as that, which makes aguish persons so cold at the beginning of the fit, though the temperature of the ambient body continue the same. But this

is not the only person, that found the sea exceeding cold; for I remember *Beguinus* relates from the mouth of a Marfeillian knight, that was overseer of the coral-fishing in the kingdom of *Tunis*, that having upon that coast let down a young man, to feel whether coral were hard or soft, as it grew in the water, when this man was come about eight fathom, near the bottom of the sea, he felt it exceeding cold. To which we shall add the testimony of a sober traveller *Josephus Acosta*, who tells us, ‘ That it is a thing remarkable, that in depth of the ocean, the water cannot be made hot by the violence of the sun, as in rivers: finally (he subjoins) even as salt-petre (though it be of the nature of salt) hath the property to cool water, even so we see by experience, that in some parts and havens, the salt water doth refresh: the which we have observed in that of *Callao*, where they put the water or wine, which they drink, into the sea in flaggons to be refreshed: whereby we may undoubtedly find, that the ocean hath this property, to temper and moderate the excessive heat.’ For this cause we feel greater heat at land than at sea, *cæteris paribus*, and commonly countries lying near the sea are cooler than those that are farther off. By all these testimonies, it seems to appear, that both in very cold regions, and very hot, the deep parts of the sea seem to be very cold, the sun-beams being not able to penetrate the sea to any great depth: for I remember, that having enquired of the diver I lately mentioned, whether he could discern the light of the sun at any great distance from the surface of the water, he answered me, that he could not; but as he went down deeper and deeper, so he found it darker and darker, and that to a degree, that would scarce have been expected in so diaphanous a body as water is.

Beguinus
in *Tyrocinio*
Chymico,
lib. 2. c. 1.

Josephus
Acosta lib.
2. cap. 11.

17. BUT this submarine cold (if I may so call it) though it be great and considerable, is not so intense, as to intitle water to be the *Primum Frigidum*; since as cold as our divers found it at the bottom of the sea, they did not find it cold enough to freeze the water, as the air often does at the top.

18. THE next opinion, we are to consider, is that of the Stoicks of old, and adopted by the generality of modern philosophers, that are not Peripateticks, who assert the air to be the *Primum Frigidum*: but being ere long more particularly to treat of the temperature of the air, we will reserve till then to examine, whether it be cold of its own nature or not; but in the mean time, we shall here take leave to question, whether it ought to be esteemed the *Primum Frigidum*. For not to mention, that *Aristotle*, and the schools, with many other learned men, think the air so far from being the coldest of the elements, that they reckon it among the hot ones, because I confess their opinion is not mine, not to represent the heat of the air in the torrid zone, nor that by the generality of philosophers, the upper region of the air, which is believed to make incomparably the greatest part of it, is always hot, and the lower region is so too, in comparison of the middle, though the coldness even of this is not perhaps unquestionable; not to urge any of these things, I say, I shall in this place mention only two observations.

19. THE one is that, which I lately recited, touching the great coldness of the water in the deeper parts of the sea; for it is not easy to shew, how this great cold proceeds from that of the air, whose operation seems not (as may be judged by that little way that frosts pierce into the moist earth) to reach very far beneath the surface of the water, (inasmuch that captain *James*, who had very good opportunity to try, allows not, in case the ice be not made by accumulation, that the frost pierces above two yards perpendicularly downwards from the surface of the water, even in the coldest habitable regions.) And this will seem the more rational, if we consider, that in case the coldness of the sea proceeded constantly from the air, as such,

the cold would be greater near the surface, where it is contiguous to the air, than in the parts remoter from it; and yet the contrary may appear by the passages lately recited.

20. BUT if it be objected, that this at best can prove no more, than that the air is not the *Primum Frigidum*; notwithstanding which, it may be the *Summum Frigidum*. For answer, I must proceed to my second argument, which will perhaps evince, that it is not that neither; for by the same way of arguing, by which those, I am now dealing with, endeavour to prove the air to be the coldest body in the world, I shall endeavour to prove, that it is not so: for their grand, and (as far as I remember) their only considerable argument is drawn from experience, which shews, that water begins to freeze at the top, where it is exposed to the air. But to this vulgar experiment I oppose that of mine, which I have often mentioned already to other purposes, that by an application of salt and snow, I can make water, that would else freeze at the top, begin to freeze at the bottom, or at any side I please, and that much sooner than the common air, even in a sharp frosty night, would be able to congeal it: and when in exceeding cold weather the ambient nocturnal air had reduced a parcel of air, purposely included in a convenient glass, to as great a degree of condensation as it could; I have more than once, by the external application of other things, been able to condense it much farther: which argues, that it is not the air as such, but some adventitious frigorifick corpuscles (taking that term, as I do in this treatise, in a large sense) that may sometimes be mingled with it, which produce the notablest degrees of cold, or upon whose account the air produces them. And if these be duly applied, water will be congealed, whether air comes to touch the surface of it or no; nay, though bodies, which the air can never penetrate, or congeal any of their parts, be interposed, as may appear by the experiments formerly mentioned of freezing water included in glass bubbles, and suspended in oil of turpentine, and other uncongealed liquors; and it is worth taking notice of by them, that conclude the air's being the *Primum Frigidum*, from the water's beginning to freeze at the top, where it is contiguous to the air, that it is there also, where the ice begins to thaw.

21. BESIDES the three opinions we have hitherto examined, there is a fourth, that justly deserves to be seriously considered; for the learned and ingenious *Gassendus* is supposed, though I doubt how truly, to be the author of it; and though, according to his custom, he speaks warily, and not so confidently of it, yet in his last writings he much countenances it; yet some eminently learned men, as well of our own, as of other nations, have resolutely enough embraced it. According then to these, the congelation of liquors, and the cold we meet with in the air, water, and other bodies, proceeds from the admixture of nitrous exhalations, or corpuscles introduced into them: and as I have a great respect for divers of these men's persons, so I like very well, in their opinion, that they do not ascribe the supreme degree of frigefactive virtue to the air itself, but to some adventitious thing, that is mingled with it: but whereas they pitched upon nitre, as the grand universal efficient of cold, I confess I cannot yet fully acquiesce in that tenet. For though I am not averse from allowing salt-petre to be one of those bodies, that are endued with a refrigerating power, and to be copiously enough dispersed through several portions of the earth; yet, for aught I know, there may be not only divers other causes of cold, but divers other bodies qualified to be efficient of cold, as well as salt-petre.

22. AND first, if cold be not a positive quality, but the absence of heat, the removing of calorifick agents will in many cases suffice to produce cold; without the introduction of any nitrous particles into the body to be refrigerated. But
because

because it is disputable, whether cold be a positive quality or no, we will urge this argument no further, till the controversy be decided; and till then, as it will remain not improbable, we propose it as no other, but proceed to the next.

23. IN the second place, I see not as yet any proof, that the great cold, we have formerly mentioned to be met with in the depths of that vast body, the sea, especially when it is greater elsewhere than nearer the top, where the air may better communicate its coldness to it, must be the effect of nitrous atoms, which must certainly swarm in prodigious multitudes, to be able to refrigerate every drop and single particle of so stupendously vast a body as the ocean. Besides that I remember not to have found or known it observed, that nitre, especially in vast quantities, reaches near so deep in the earth, as those parts of the sea, that are found exceeding cold. And as the halituous part of nitre is more disposed to fly up into the air, than drive down into the sea; so we find no great documents of its having its grosser and sensible parts abounding in the sea-water, since the evaporations of that leaves not behind it salt-petre, but common salt. But these, though no light considerations, are not those, that most weigh with me.

24. FOR, in the next place, I am not satisfied with the experiences I find alledged to prove, that it is by nitre, that the air and the neighbouring parts of the earth, and water (not to repeat the objections I lately borrowed from the sea) receive their highest degrees of cold. For when *Gassendus* and others tell us, that it is nitre resolved into exhalations, that makes the gelid wind, which refrigerates all things it touches, and penetrating into the water, congeals it; this, I say, to me will seem precarious, until *Gassendus* (or some other for him) tells us, what experiments they are (which he seems in one place to intimate) that this new doctrine depends on: for I confess, that for my part, I, who have perhaps had more opportunity to resolve nitre, have seen no great feats, that the steams of it have done, more than those of other saline bodies, in the production of cold; and the spirit of nitre, which is a liquor consisting of the volatile parts of that resolved salt, not only does not (that I have observed) appear to the touch to have considerably, if at all, a greater actual cold, than that of divers other liquors, but seems to have a potential heat. For whether or no the exhalations of nitre be able to congeal water into ice, I have formerly observed, that the spirit of nitre or aqua fortis will dissolve ice into water, very near, if not altogether as soon as the spirit of wine it self; which inflammable liquor is generally acknowledged to be in a high degree potentially hot. If *Gassendus* did not mean such steams of salt-petre as these, which I have been speaking of, it had not been amiss to have signified, what other kind of corpuscles of resolved nitre he meant, without leaving his reader to divine it: and if we may judge of other experiments, which we lately took notice, that *Gassendus** seems to intimate by that, which he sets down a little after, compared with that he had mentioned a little before; I am not likely much to be convinced by them, but shall rather be tempted to suspect, that learned man might be imposed upon by others to write that, as matter of fact, which he never had tried, and yet own not the having it by report. For whereas he seems to say, that dissolved nitre mingling itself with water, freezes it, and that in summer; yet I must freely profess, that

* *Gassendi Phys. Lib. 6. Sect. 1. pag. 399. De qualitatibus rerum — ac addi quidem fortassis potest, præcipua frigoris semina, si quæ constant, potissimum ex frigorificis atomis abire in halinitrum corporaque ipsi affinita, quando experimur non exsolvi halinitrum, quin et penetrando in aquam, ipsam congelet, et universa a se contacta refrigeret, et abeundo in halitum creet gelidum seu frigidum ventum, sed res pendet ex variis, quæ non possunt hoc loco commemorari, experimentis.*

although some other learned moderns teach the same thing (but without any man's avouching it, that I know, upon his own experience) I, who am no stranger to nitrous experiments, have never been able to produce, or so fortunate, as to see any such effect: and it is somewhat strange to me, that chymists, who make such frequent solutions of nitre, and oftentimes with less water than is sufficient to dissolve it all, so that by consequence the proportion of the nitre to the water must have run through almost all the possible measures of proportion, should never so much as by chance (as I can hear) have observed any such matter. And that, which makes me thus interpret *Gassendus* his meaning, (though in one of the two passages, wherein he sets down this experiment, he mentions also snow, or ice, to be added to the nitre) is, that in the first of those two passages, he ascribes the congelation to nitre alone, without speaking of either ice or snow; and in the other place, not only his words seem to import †, that notwithstanding the addition of the other ingredients, the corpuscles of the nitre expiring out of the mixture, and penetrating into the water, are they, that make it freeze; but the exigence of his discourse seems to require such an interpretation: for to say, it is the corpuscles of the nitre, that were harboured in the ice or snow, that freeze the water they invade, is no better than to beg the question. For besides that he ought to prove, that there are multitudes of the corpuscles of nitre lodged in snow and ice; besides this, I say, since these two bodies are said to be water, before they were congealed, to grant what his explication supposes about ice and snow, is to grant in effect, that nitre alone (without ice or snow) can turn water into ice, which is the thing, that experience warranted us lately to deny. And if this be all, that is meant by the experiment, the mixing of nitre with the ice, or the snow, will signify very little, to evince what should be proved. For, if instead of nitre you take sea-salt, or the spirit of salt, nay, the inflammable part of wine, the experiment will succeed; and yet I think *Gassendus* would not have the corpuscles of these bodies to be frigorifick, like those of nitre; which yet they may be proved to be by the same argument, which is employed to shew, that the corpuscles of the nitre, which is added as a distinct ingredient to the ice, or to the snow, are the efficientes of the congelation.

25. HAVING thus examined *Gassendus* his experiments, we will now, as our next and last argument touching this subject, subjoin our own, as far as we can find any of them among our notes; some of which follow in these words:

26. [As cold as they think salt-petre to be, who teach its spirituous parts to be the grand and catholick efficientes of cold, yet we found, that it would dissolve ice readily enough, as well as sea-salt, &c. are wont to do, as we collected from this, that roch'd petre mingled with ice would freeze the vapours wandering in the air to the outside of the single phial, wherein we made the experiment, which the ice alone would not have done; and having placed some grosser beaten nitre (of the same parcel) in little heaps here and there upon plates of ice, we manifestly found them to sink into the ice, which argued their dissolving it; and having put some of it upon a thick and smooth piece of ice, we found, that it had pierced a hole quite through it, whilst the surrounding part of the ice remained of a good thickness.]

27. [WE took a large single phial, almost full of water, and put it into as much roch'd petre, as by keeping it a good while by the fire's side, we could dissolve in it; of which one mark was, that there remained a pretty deal of salt intire at the bottom

† b. pag. 400. *Quomodo possunt corpuscula nitri in aquam infusi illam præter modum adeo frigidam reddere, imò et per æstatem etiam congelare, dum nitrum nivì glaciive detritæ commistum lagenæ circumponitur, ipsæque præter corpus lagenæ penetrant in aquam contentam.*

of the liquor: this being exposed to the air, during an extremely sharp night, and a good part of the day, the solution was frozen so hard to the very top of the liquor, that having broken the glass, we could hardly break the included mass. But at the bottom there appeared some liquor, with crystals of nitre well figured, that seemed to have shot in it, and argued the water to be sufficiently impregnated with the salt.]

28. [As for the spirituous parts of nitre, so far forth as their temper, as to heat or cold, can be judged by distillation, and by weather-glasses, they are not actually more cold than some other liquors, and appear rather to be potentially hot, than cold; at least, they seem indisposed to turn water into ice, since we have tried, that the spirit of nitre will readily enough turn ice into water.]

29. THESE three foregoing notes shew, that salt-petre is no such wonderfully cold body, but that there are others colder, as being able to freeze water, which nitre could not congeal. Nay, they manifest, that nitre, which is said to be the efficient of ice, does thaw and dissolve it, and so seems, at least in reference to it, to be rather hot than cold.

30. I shall add now one note more, to shew it does not always make water so much as equally cold with the common air; the experiment I find thus recorded.

31. [WE took a sealed weather-glass, and by a little pulley fastened to a frame, suspended it in a solution of rock'd petre, as strong as we could make it, without heat; as appeared by a pretty quantity of nitre, that had continued some days undissolved in the vessel, which was a beer-glass, with a flat bottom. After the ball of the weather-glass had been suspended in this liquor, to try, whether the ambient air were not at this time colder than the liquor, (it being a cloudy and windy day, and betwixt the hours of 11 and 12) though both the weather-glass and it had stood some days in the place; I lifted up the glass out of the water by the string it hung by, that I might not touch it with my warm hands, and found the liquor in the glass to descend by degrees, about two divisions, (which were eighths of an inch) and then by the string lifting up the weather-glass, and putting again the solution of nitre under it, the included liquor was impelled up again two divisions, and sometimes two divisions and a half: for to satisfy my self the more fully, I repeated the experiment several times, and observed, that the included liquor usually ascended the first division so fast, that the eye could perceive its progress, and that the ascent upon the immersion in the dissolved nitre was discernibly quicker than the descent, upon the removal of the weather-glass into the open air, though the space both of the one and of the other were about, either two divisions, or two divisions and a half.]

32. IF it be here demanded, what then I think of the frigifactive virtue of nitre, I must answer, that I have not yet fully satisfied my self concerning it: but thus much I am not willing to deny, that among divers other bodies, that upon several occasions exhale from the terrestrial globe, those corpuscles, that are of a nitrous nature, may be for the most part well qualified to refrigerate the air. And I am not indisposed to think, that there may be store of little saline bodies of kin to nitre, that (especially at certain times) rove in great multitudes to and fro, in some parts of the atmosphere; but that this aerial salt, which some moderns call volatile nitre, should be true and perfect salt-petre, is more than I am sure of, and that this salt alone should be the *Summum Frigidum*, is more than as yet I am convinced of; especially, since, for aught I know, there may be in the bowels of the earth, (whence I have seen many concretes digged out, whose very names and outides are for the most part unknown, even to chymists themselves) divers other bodies besides salt-petere, whose steams may have a power of refrigerating the air, as great in proportion to their quantity, as those of salt-petre. And since common salt in artificial glaciations is found to co-operate

as

as powerfully as salt-petre itself; and since it is undeniably a body, of which there is a vast quantity in the terrestrial globe, and which by reason of the sea, where it abounds, is exceedingly diffused; I see no great reason, why we may not as well esteem that kind of salt among the catholick efficientes of cold, and the rather, because that the smallest corpuscles our eye discerns of sea-salt, are wont to be (though not exactly) of a cubical figure: which is that figure, *Philoponus* informs us, the great *Democritus* of old (justly admired by *Gassendus*) assigned to the atoms of cold: whereas, according to *Gassendus* himself, the corpuscles of nitre, at least as far as sense has informed us, are not the most conveniently shaped to produce cold, since he labours to shew, that the figure of frigoris atoms is to be tetrahedral or pyramidal: whereas the crystals, or grains, great or small, into which good salt-petre shoots, are wont to be prismatical, having their base sexangular. But to return to what I was saying concerning the congealing of water with ice, I shall subjoin, that the same experiment countenances my conjecturing, that oftentimes it may not be emanations of one salt, or other body, but a peculiar and lucky conjunction of those of two or more sorts of them, that produces the intense degree of cold; as we see, that ice and snow themselves have their coldness advanced (as to its effects) by the mixture either of sea-salt or nitre, or spirit of wine, or any other appropriated additaments. Nay, I may elsewhere have occasion to shew, that actual cold may be manifestly promoted, if not generated, by the addition of a body, that is not actually cold. But to all this I must add, that I doubt, whether any of those saline or terrestrial exspirations, either single or conjoined, be the adequate causes of cold; since, for aught I know, there may be other ways of producing it besides the introduction of frigoris atoms, whether atoms or corpuscles, of which we may have occasion to take some notice hereafter. In the mean time, having discoursed thus long against the admitting a *Primum Frigidum*, I think it not amiss to take notice once more, that my design in playing the sceptick on this subject, is not so much to reject other men's probable opinions of a *Primum Frigidum*, as absolutely false, as it is to give an account, why I look upon them, as doubtful.

T I T L E XVIII.

Experiments and observations touching the coldness and temperature of the air.

1. **I** HAVE shewn in the former section, that the air is not the *Primum Frigidum*; but yet I cannot readily yield my assent to the opinion of the learned *Gassendus*, and some others, (who have written before and since him) that the air is of itself indifferent; that is, neither cold, nor hot, but as it happens to be made either the one or the other by external agents. For if we take cold in the obvious and received acceptation of the word, that is, for a quality relative to the senses of a man, whose organs are in a good or middle temper, in reference to cold and heat; I am hitherto inclinable to think, that we may rather attribute coldness to the air, than either heat, or a perfect neutrality as to heat and cold. For to make a body cold as to sense, it seems to be sufficient, that its minute corpuscles do less agitate the small parts of our organs of feeling, than they are wont to be agitated by the blood, or other fluid parts of the body; and consequently, if supposing the air devoid of those calorific and frigoris atoms, to which the learned men, I was naming, ascribe its heat and cold, it would constitute a fluid, which either by reason of the minuteness of its parts, or their want of a sufficiently vehement motion, would less affect the sensory of feeling, than the internal liquors and spirits of the body are wont to do, and so it would appear actually cold. Nor is it necessary, that all liquors, much less all fluids,

should be as much agitated as the blood and vital humours of a human body, as we see (to omit what in the last section is mentioned about newly emitted urine, and to skip other obvious instances) in those fishes and other animals, whose blood and analogous juices are always, and that in the state, which passes for their natural state, actually cold to our touch. And I see no sufficient reason, why we should not conceive the air even in its natural state, (at least as far forth as it can be said to have a natural state) to be one of the number of cold fluids. For as to the main, if not only, argument of *Gassendus*, and others, namely, that as we see the air to be easily heated by the action of the sun, or the fire, so we see it as easily refrigerated by ice, and snow, and northerly winds, and other efficient causes of cold, and that heat and cold reign in it by turns in summer and in winter; this only proves, what I readily grant, that the air is easily susceptible at several times of both these contrary qualities; but it does not shew, that one is not more connatural to it than the other; as we see, that the water may be easily deprived of its fluidity by the circumposition of snow and salt, and reduced to be fluid again by the sun, or the fire; and yet, according to them, as well as to others, fluidity, not firmness, is the natural quality of water. But this is not that, which I lay most weight upon; for I considered, that it is manifest, and acknowledged by these learned men themselves, that the heat of the air is adventitious to it, and communicated by the beams of the sun, or of the fire, or by some other agents naturally productive of heat, as well in other bodies as the air. And it is also evident, that upon the bare absence (for aught else, that appears) of the sun, or extinction of the fire, or removal of the other causes of heat, the air will, as it were, of its own accord, be reduced to coldness. Whereas, that there are swarms of frigorific atoms diffused through the air, from which all its coldness proceeds, is but an hypothesis of their own, far from being manifest in itself, and not hitherto, that I know of, proved by any fit experiment, or cogent reason. And though in some cases I am not adverse to the admitting such corpuscles, as may in a sense be styled frigorific, yet I see not, why we should have recourse to them in cases, where such a bare cessation, or lessening of former motion, as may easily be ascribed to manifest causes, may serve the turn, as to a *sensible* (for I now consider not the causes of the *intenser*) coldness in the air, without taking them in. And the opinion, I incline to, has at least this advantage, that the air seems to be as rightfully termed cold, as iron, marble, mercury, crystal, salt-petre, and such other bodies, which men unanimously look upon as such; there being none of these, to which the argument employed against the coldness of the air, is not applicable, save that the air being a fluid of a looser and finer texture, does sooner receive and lose the impressions of heat and cold. And yet if a block of marble, for instance, or an iron bullet, were removed into one of those empty spaces, that *Gassendus*, and some others, supposed to be beyond the bounds of this world, I see not, why it should not be rather cold, than either warm, or in a state of perfect neutrality; since when the corpuscles of heat and those of cold had extricated themselves, and were flown away into the neighbouring vacuum, the component particles of the stone or metal, whose implicated texture would hinder their diffision, remaining much less agitated than our organs of feeling are by the warm blood and spirits, that vivify them, must, if applied to those sensories, appear cold.

2. I SHALL not, upon this subject, spend any farther discourse, since perhaps the dispute either may be, or at least may easily be made verbal; for in case those I argue with, should so explain their opinion, as not to deny, that in its own nature the air, left to itself, may be reputed cold in reference to the sensories of men, who are warm animals; but say, that nevertheless, comparing it indefinitely to other than human bodies.

bodies here below, it is so easily susceptible of both the contrary qualities, that neither of them seems predominant in it, and that when it is considerably either cold or hot, it is made so by adventitious agents; I shall not much contend with them, especially if it can clearly be made out, that there are great quantities of such cold spirits, as *Cabæus* and *Gassendus* supposed to be universally productive of cold (more or less) in all bodies, where they get admission: but of these cold spirits more perhaps elsewhere; our principal business in this section being to deliver experiments and observations; and because we shall mention but few of the former sort, we will dispatch them first.

[3. *November* the 20th, 1662, we took a weather-glass, filled to a convenient height, with well-rectified spirit of wine, and hermetically sealed: this we inclosed in a glass receiver of a cylindrical form, of about two inches diameter, and about a foot and a half high, and having cemented on the receiver, we let it alone for some hours, that it might be perfectly cool. Then drawing out the air, and watching it narrowly, we observed, that the liquor in the weather-glass descended a little, though but a very little, upon the first exsuction of the air, and a little, though it seemed somewhat less, upon the second; but afterwards we did not find it sensibly to descend. This subsidence of the liquor, in all amounting to about the length of a barley-corn, we attributed to the stretching of the glass by the spring of the included air, when the ambient was withdrawn; and accordingly, upon our allowing a regress to the excluded air, we saw the spirit in the thermometer rise about half a barley-corn's length to the place, whence it began to subside. Afterwards we sucked out, and let in the air of the receiver, as before, with like success, as to the descent and remounting of the liquor.

4. *N. B.* We tried with a very hot handkerchief applied to a convenient place on the outside of the receiver, whether the included weather-glass would receive impressions from it, the air, that was wont to be intermediate, being removed: but we did not find the liquor in the weather-glass sensibly to swell, either by this way, or by casting upon it the concentrated beams of a candle trajected through a double convex-glass. But when the air was re-admitted into the cavity of the receiver, then the same handkerchief, heated afresh, and applied, made the spirit of wine sensibly, though but little more, to ascend: of which, yet it seemed something difficult, by reason of the nicety of the experiment, to estimate with any thing of certainty the cause.] So that upon the whole matter, till the experiment be repeated in air of differing tempers, to verify, whether it was the withdrawing of the wonted pressure, or the recess of the substance of the air, that made the liquor included in the thermoscope subside, and till the experiment be repeated with the further observation of other circumstances, (which reiteration of the trial we intended, but were by intervening accidents hindered) the recited experiments will not afford much more than good hints towards the discovery of the temperature of the air.

* In the third preliminary discourse.

I HAVE elsewhere * taken notice, that air, included in vessels sufficiently strong and well closed, was not sensibly or at least considerably condensed by cold; but when the air was not so included, as not to be in some part or other exposed to the pressure of the outward air or atmosphere, it would then by a degree of cold, capable to freeze water, be manifestly reduced into a less room. But how much this contraction or condensation of the air may amount to, I did not there subjoin, nor has the measuring of it been, that I know of, attempted by any man. Wherefore we thought fit to endeavour something in this kind, of which we shall annex a brief account, whereby it will appear upon the whole matter, that in the climate we

live in, the cold does not so considerably condense the air, as most men seem to have hitherto imagined.

6. AND first, it will not be amiss to intimate, that among other ways we tried to measure the shrinking of the air by sealing it up in glasses furnished with long and very slender stems, that by breaking off the tips of those glasses immersed under water, when by the cold air of a frosty night, or the circumposition of snow and salt, the included air was highly refrigerated, the water might (by the pressure of the atmosphere upon it) be impelled into the cylindrical cavity of the broken glass, and by its greater or lesser ascent therein shew, how much the internal air had been made to shrink upon the account of the cold. But this way, for reasons too long to be here deduced, we found troublesome and difficult to practise with any thing of certainty. Nor did we ever, that I remember, by this way, bring the refrigerated air to lose above a 30th part of its former dimensions.

7. WE would have tried also to measure the condensation of the air by the ascent of water into the stem of a bolt-head, so invented, that the orifice of the stem might be under the surface of the water, and the bolt-head kept erected. But this way we disapproved, because it was likely (and indeed we found it so by experience) that the external air would first freeze the uppermost part of the water contained in the stem, and thereby hinder its ascent, and perhaps occasion the bursting of the lower part of the said stem.

8. WHEREFORE, though for want of a sufficient quantity of some liquor, that would neither freeze like water, and aqueous bodies, nor congeal like common oil, and the like unctuous juices, we found it for a while somewhat difficult to practise the experiment; yet bethinking ourselves of the indisposition, that brine has to congelation, we made so strong a brine with common salt, that with it (and, as I remember, with oil of turpentine also, of which we chanced to have some quantity by us) we made divers trials, of which I had two among our collections, which we shall here subjoin; whereof the one informs us, that an egg being inverted into salt water, the cold of a frosty night made the air shrink in the pipe near five inches; and the other (which is the accuratest I meet with among my collections) gives me this account, that *January* the 29th, the air extending into 2057 spaces, was by the cold of the sharp and frosty night contracted into 1965 spaces; so that in extraordinary cold weather, the most we could make the air lose of its former dimensions by the additional cold of the atmosphere, was a twenty-second part, and a little more than a third. And this was the greatest condensation of the air, that we remember ourselves to have observed, though we were so careful, as after we had placed marks, where the incongealable liquor reached into the pipe, that when the internal air was exposed abroad to the cold, we caused servants to watch, and from time to time to take notice (by placing marks) of the various ascents of the liquor, especially early in the morning, lest we should omit taking notice of the greatest contraction of the air; which omission (by reason that the coldness of the ambient air does oftentimes begin to be remitted before we can feel it to be so) is not easily avoided without watchfulness.

9. BUT having thus observed the condensation of included air by the natural and unassisted cold of the external air, we thought fit to prosecute the trial somewhat further; and in regard we conceived the cold of a mixture of snow and salt to be far more intense, than that of the meer ambient air alone, we endeavoured to measure, as near as we could, how much the one exceeded the other. And though we found, that by prosecuting the lately mentioned trial in the glass-egg, by the application of ice and salt to the elliptical part of the vessel, the liquor rise by our estimate near four

inches more (than those five, which it had risen already, upon the account of the refrigeration of the included air by the bare cold of the external) yet by prosecuting the other experiment (made the 29th of *January*) at the same time, when we were making it, we did somewhat more accurately determine the matter. For by applying ice and salt to the outside of the vessel, we found, that the included air was contracted from 1965 spaces, to which the cold of the ambient air had reduced it, into 1860 spaces; so that the circumposition of ice and salt did as much, nay somewhat more, condense it, after the meer cold of the external air had contracted it as far as it could, than the bare, though intense, cold of the ambient air could condense it at first; and the greatest degree of adventitious cold we were able to give, by the help of nature and art, did not make the air exposed to it lose a full tenth part of its former dimensions. On which occasion it may not be unworthy observation, that there is no greater disparity betwixt the proportion, in which the cold was able to condense the air, and that, wherein the cold was able to expand water.

10. THIS is all that at present I think fit to say, concerning the interest, that winds may have in the temperature of the air. And therefore I will now proceed to those other particulars, wherewith I not long since said, that I intended to close up this section; and I might on this occasion subjoin many things, but partly haste, and partly other considerations will confine me to those, that relate to the effects of cold upon the air in a more general way.

11. AND first, we will observe, that cold may hinder, in an almost incredible measure, the warming operation of the sun upon the air, not only in the hottest part of the day (for that may sometimes happen, even in our climate) but at several times of the day, even in the heat of summer.

12. I REMEMBER I once accidentally met with an intelligent and sober gentleman, who had several times sailed upon the frigid zone, and though an intervening accident separated us so suddenly, that I had not opportunity to obtain from him the resolution of above two or three questions; yet this I learned of him belonging to our present purpose, that by the help of a journal he kept, he called to mind, that upon the coast of *Greenland* he had observed it to snow all midsummer night; which affirmation of so credible a person imboldens me to add some other relations, which I should else have scrupled at.

13. MR. *Logan*, an English merchant, that wintered at *Pecora*, one of the northern towns of *Muscovy*, relates, that being there at a great salmon-fishing, there happened about the close of *August* (which in many countries is wont to be the hottest time of all the year) so strong a frost, which lasted till the fourth day, *Purchas*, lib. 4. pag. 542. 'That the *Ozera* was frozen over, and the ice driving in the river to and again, broke all the nets; so they got no salmon, no not so much as for their own victuals.'

These voyages are extant in *Purchas*, lib. 1. cap. 13. and this passage is in pag. 560.

14. CAPTAIN *G. Weymouth* mentions, that in *July*, though he was not near the latitude of *Nova Zembla*, much less of *Greenland*, yet sailing in a thick fog, when by reason of the darkness it occasioned, *Purchas*, pag. 811. 'he thought good to take in some of his sails; when his men came to hand them, they found their sails, ropes, and tacklings so hard frozen, that it did (says he) seem very strange unto us, being in the chiefest time of summer.'

15. IN the fifth voyage of the English to *Cherry Island*, which lies betwixt 74 and 75 degrees of latitude, they observed, that the wind being at North-east upon the 24th of *July*, 'it froze so hard, that the ice did hang on their clothes.' And in the seventh voyage (which was made three years after) to the same island, they mention,

Purchas, pag. 564. that on the 14th of July, 'the wind being northerly, they had both snow and frost.'

16. THE next thing, that we shall take notice of, is the degree of cold, which the efficient causes of that quality, whatever they be, are able to produce in the air; but of this we must not here treat indefinitely, the strange effects of cold upon other bodies being most of them produced by the intervention of the cold first diffused in the air, and those are treated of in a distinct section: wherefore we shall now give two or three instances of the sudden operations of the cold harboured in the air.

THE formerly mentioned English ambassador into *Russia*, Dr. *Fletcher*, gives us two instances very memorable to our present purpose: *Purchas*, pag. 415: 'When you pass (says he) out of a warm room into a cold, you will sensibly feel your breath to wax stark, and even stifling with the cold, as you draw it in and out.' So powerfully and nimbly does the intensely refrigerated air work upon the organs of respiration.

[AND whereas a very credible person, now chief physician to the *Russian* emperor, being asked by me concerning the truth of what is reported sometimes to happen at *Moscow*, and is reputed the eminentest proof, that is readily observable of the extreme coldness of the air, assured me, that he himself saw the water thrown up into the air fall down actually congealed into ice; Dr. *Fletcher* confirms this report.] For our ambassador also says, *Purchas*, pag. 414. 'That the sharpness of the air you may judge of by this, for that water dropped down, or cast up into the air, congealed into ice, before it come to ground.' And I remember, that inquiring about the probability of such relations, he answered me, that being at the famous siege of *Smolensko* in *Russia*, he observed it to be so extremely cold in the fields, that his spittle would freeze in falling betwixt his mouth and the ground; and that if he spit against a tree, or a piece of wood, it would not stick, but fall to the foot of it.

17. AMONG the phenomena of cold, relating to the air, I endeavoured to observe, whether, upon the change of the weather from warm or mild to cold and frosty, there would appear any difference of the weight of the atmosphere by its being plentifully furnished with a new stock of such frigorifick corpuscles, as several of the modern philosophers ascribe its coldness to: but though I several times observed by comparing a good barometer (and sometimes also unsealed weather-glasses, furnished one with a tinted liquor, and the other with quicksilver) with a good sealed weather-glass, furnished with pure spirit of wine, that, upon the coming in of clear and frosty weather, the atmosphere would very early appear sensibly heavier than before, and continue so, as long as the cold and clear weather lasted; yet by reason of some considerations and trials, that bred some scruples in me, I refer the matter to more frequent and lasting observations, than I yet have been able to make; in which it will concern those, that have a mind to prosecute such trials, not only to consider, whether or no the increased gravity of the atmosphere may not proceed from some other cause, than the coming of frigorifick atoms into the air; but to have a special care, that their baroscopes be more carefully freed from the air, that is wont to lurk in quicksilver it self, as well as other liquors, than those, in the making of the Torricellian experiment, tubes usually are, lest that air getting up into the deserted part of the tube, do, by its expansion and contraction, obtain an unsuspected interest in the rising and falling of the subjacent mercurial cylinder, and so impose upon them.

18. ANOTHER effect, that the cold, especially in northern countries, has oftentimes upon the atmosphere, is, the making the air more or less clear than usually it is. For in the northern voyages, the seamen frequently complain of thick and lasting fogs, whose causes I shall not now consider, but some help to guess at them may be given by what we are about to add; namely, that it frequently happens, on the contrary, that when the cold is very intense, the air grows much clearer than at other times, probably because the cold by condensing precipitates the vapours, that thicken the air, and by freezing the surface of the earth, keeps in the steams, that would else arise to thicken the air. Not to dispute, whether it may not also somewhat repress the vapours, that would be afforded by the water it self, since some of our navigators observe, that even when it was not cold enough to freeze the surface of the sea, it would so far chill and inrigidate it, that the snow would lie on it without melting.

19. I REMEMBER a *Swedish* extraordinary ambassador, and a very knowing person, whom I had the honour to be particularly acquainted with, would say, when he saw a frosty day accompanied with great clearness, that it then looked like a *Swedish* winter; where, when once the frosty weather is settled, the sky is wont for a very long time to be very serene and pleasant; and here in *England* we usually observe the sharpest frosty nights to be the clearest. But to confirm our observation by a very remarkable instance, I shall borrow it from a navigator very curious of celestial observations; which circumstance I mention to bring the greater credit to the following observation of Captain *James*, which in his journal, pag. 62. is thus delivered: 'The thirtieth and one and thirtieth of *January*, there appeared in the beginning of the night more stars in the firmament, than ever I had before seen by two thirds. I could see the cloud in *Cancer* full of small stars.'

20. To determine what effect the coldness of the air may have upon the refractions of the luminaries and other stars, I look upon as a work of no small difficulty, and that would require much consideration as well as time: wherefore I shall only add two or three narratives, supplied me by navigators, without adding at present any thing to the matters of fact.

21. THE first is that famous observation of the *Dutch* in *Nova Zembla*, who take great pains to evince, by several circumstances, some of them highly probable, that they were not mistaken in their account of time; according to which, they concluded, that they saw the sun, whom they had lost sight of eleven weeks before, about fourteen days sooner than he ought to have appeared to them: which difference has been, for aught I know to the contrary, by all that have taken notice of it, ascribed to the strangely great refraction in that gelid and northern air.

22. AND as for that other extremely cold country, where Captain *James* wintered, it appears by his journal, that he there made divers celestial, and other observations, which gave him opportunity to take notice of the refraction; and he seems to complain, that he found it very great, though among the particulars he takes notes of, there are some, that seem not very strange, nor are there any, that are near so wonderful, as that newly mentioned of the *Hollanders* in *Nova Zembla*; however in regard of the extreme coldness of the winter air in *Charleton Island*, it may be worth while to take notice of the following passages out of his journal, since they may at least help us to conjecture, what is not to be expected in reference to refractions from the coldness of the air as such, page 61. 'The 21st of *January* (says he) I observed the latitude with what exactness I could (it being very clear sun-shiny weather) which I found to be 52 deg. 32 min. This difference is by reason, that here is a great,

‘ great refraction.’ Which laft clause is very obfcure, unlefs it refers, as one may guefs it does, to what he had elfewhere faid, that on his firft coming to the ifland, pag. 46. ‘ he took the latitude with two quadrants, and found it to be juft 52 ‘ degrees,’ without any minutes. Elſewhere, pag. 64. ‘ my obſervations (ſays he) ‘ by theſe glaſſes I compared to the ſtars coming to the meridian.’ By this means we found the ſun to riſe twenty minutes before it ſhould, and in the evening to remain above the horizon twenty minutes (or thereabouts) longer than it ſhould. And this by reaſon of the refraction.

And in another place, *March* the 15th. ‘ This evening (ſays he) pag. 66. the ‘ moon roſe in a very long oval alongſt the horizon.’

I SHALL add one paſſage more out of our author, concerning refractions, not only becauſe it may bear testimony to ſome relations of the like kind, that I have mentioned in another treatiſe; but becauſe it is concluded with an obſervation, that (if there be nothing of miſtake in it) is odd enough. ‘ I had often (ſays he) pag. 69. ‘ obſerved the difference betwixt clear weather and miſty refractious weather in this ‘ manner. From a little hill, which was near adjoining to our houſe, in the cleareſt ‘ weather, when the ſun ſhone, with all the purity of air that I could conceive, we ‘ could not ſee a little iſland, which bare off us ſouth ſouth-eaſt ſome four leagues ‘ off; but if the weather were miſty (as aforeſaid) then we could often ſee it from ‘ the loweſt place.’

23. HITHERTO I have treated of the temperature of air in general; and though the paſt diſcourſe have been prolix enough, yet poſſibly I may have no fewer things to ſay, if I would at preſent fall upon the conſideration of the three regions, into which the air is wont to be diſtinguiſhed. For I confeſs I am not altogether without ſcruples, both as to the number, and as to the limits, and as to the qualities aſſigned to theſe aerial regions. But (as I have partly declared in another * tract) though I had time to enter upon ſo intricate a diſquiſition, yet till I have an opportunity to conſult ſome other papers, I know not, whether what I have noted, touching theſe difficulties, may not more properly belong to another treatiſe, than this of cold.

* A ſceptical diſquiſition of Aſtrophical Obſervations.

24. HAVING thus diſpatched the few experiments I can meet with among my papers, concerning the coldneſs of the air, I now proceed to ſubjoin ſome obſervations, that have occurred to me in the writings or verbal relations of navigators and travellers about that ſubject. But in regard, that the greateſt part of the phænomena of cold, which nature of her own accord preſents us with, ſeem to be produced, either mediately or immediately by the air, we intend not here to treat of the coldneſs of the air in the largeſt ſenſe, but only to take notice of ſome of the choicer inſtances, that ſeem to belong to our preſent argument. And theſe we ſhall annex, either as promiſcuous obſervations at the cloſe of this ſection, or as illustrations or proofs of the three following obſervations.

2. THE firſt I ſhall propoſe in theſe terms; ‘ That the greater or leſſer coldneſs of ‘ the air, in ſeveral climates and countries, is nothing near ſo regularly proportionate ‘ to their reſpective diſtances from the pole, or their vicinity to the equator, as men ‘ are wont to preſume.’

THIS puts me in mind of what I have formerly, either heard from a ſkilful man, or obſerved my ſelf about the difference betwixt places of the ſame latitude in the northern and ſouthern hemisphere; namely, that of places equally diſtant, the one from the northern, the other from the ſouthern pole, the latter are generally much colder than the former. And, as I remember, I long ſince noted ſome things to this purpoſe; but being not at preſent able to recover them, I ſhall propoſe this only, as that,

that, which may deserve an inquiry, being not yet satisfied, but that in the examples I had taken notice of, some accidental and concurrent causes may have occasioned the greater coldness observed in the places seated on the other side of the line; as, on this side of it, the like causes may much vary the coldness of differing places of equal latitudes, as we are now going to shew by the following testimonies.

1. How excessive a cold reigns at *Moscow* and thereabouts in the winter time, when many men lose their noses or their toes, and some their lives by the extremity of the cold, we have several times occasion to take notice of in this treatise. And yet at *Edinburgh*, which I find some of our modern navigators to place more northerly by above a degree; there, I say, and in the neighbouring places, the air is known to be temperate enough, and the cold very tolerable: and it is affirmed, that the snow very rarely lies any long time on the ground after it is fallen.

2. In the voyage made for discoveries northward by Mr. *Pool*, in the year 1610, I find this passage, pag. 702. ‘I was certified, that all the ponds and lakes were unfrozen, they being fresh water; which putteth me in hope of a mild summer here, after so sharp a beginning, as I have had; and my opinion is such (and I assure my self it is so) that a passage may be as soon attained this way by the pole, as any unknown way whatsoever, by reason the sun doth give a great heat in this climate; and the ice (near the 79th degree) I mean that, that freezeth here, is nothing so huge as I have seen in 73 degrees.’

To this agrees the testimony of the Hollanders in their first voyage to *Nova Zembla*, in which the writer of it, *Gerat de Veer*, speaks thus, pag. 473, 474. ‘We have assuredly found, that the only and most hinderance to our voyage was the ice, that we found about *Nova Zembla*, under 73, 74, 75 and 76 degrees, and not so much upon the sea, between both the lands; whereby it appeareth, that not the nearness of the north pole, but the ice, that cometh in and out from the Tartarian sea about *Nova Zembla*, caused us to feel the greatest cold. Therefore in regard, that the nearness of the pole was not the cause of the great cold that we felt, &c. And a little after, — ‘It is true (says he) that in the country lying under 80 degrees (which we esteem to be *Greenland*) there is both leaves and grafs, to be seen, wherein such beasts, as feed of leaves and grafs, as harts, hinds, and such like beasts, live; whereas to the contrary in *Nova Zembla* there groweth neither leaves nor grafs, and there are no beasts there, but such as eat flesh, as bears and foxes, &c. although *Nova Zembla* lieth 4, 5, and 6 degrees more southerly from the pole, than the other land aforesaid.’

AND to this purpose I remember what is related by the learned *Josephus Acosta*, concerning the heats and colds in the torrid zone, and elsewhere: *Acosta*, lib. 2. cap. 9. pag. 101. ‘When I passed (says he) to the *Indies*, I will tell what chanced unto me: having read what poets and philosophers write of the burning zone, I persuaded my self, that coming to the equinoctial, I should not endure the violent heat: but it fell out otherwise, for when I passed, which was when the sun was there for zenith, being entered into *Aries*, in the month of *March* I felt so great a cold, as I was forced to go into the sun to warm me. What could I else do then but laugh at *Aristotle’s* meteors and his philosophy, seeing that in that place, and at that season, when as all should be scorched with heat according to his rules, I and all my companions were a-cold? In truth there is no region in the world more pleasant and temperate than under the equinoctial, although it be not in all parts of an equal temperature, but have great diversities. The burning zone in some parts is very temperate,

‘temperate, as in *Quito*, and on the plains of *Peru*; in some parts very cold, as at *Potosi*; and in some very hot, as in *Ethiopia*, *Brasil* and the *Moluccoes*.’ And within two chapters after, he discourfes more largely of some of these particulars. And again chapter the 12th, ‘You may continually (fays he) pag. 109. fee upon the tops of these mountains fnow, hail, and frozen waters; and the cold fo bitter, as the grafs is all withered, fo as the men and beafts, which pafs that way, are benumbed with cold. This, as I have faid, is in the burning zone, and it happens moft commonly, when they have the fun for zenith.’

THESE testimonies of a learned man, that writes upon his own knowledge, I thought worth producing, to make it probable, that as in feveral countries the heat does not always answer to the nearness of places to the line; fo in northern regions the cold may not always be proportionate to their vicinity to the pole. In Mr. *Hudson’s* fecond voyage, written by himfelf, he mentions, that above 71 degrees, though they were much pestered with ice, about the end of *June*, ‘that day (when this happened, *Purchas*, pag. 578. was calm, clear, and hot weather; adding of the next day alfo, that it was calm, hot, and fair weather.’ And *Acofta* tells us, that we fee these differences, not only on the land, but alfo on the fea: there are fome feas, where they feel great heat, as the report of that of *Mazambique*, and *Ormuz* in the East, and of the fea of *Panama* in the West. There are other feas in the fame degree of height very cold, as that of *Peru*, in the which we were a-cold, when we firft failed it, which was in *March*, when the fun was directly over us. In truth, on this continent, where the land and fea are of one fort, we cannot imagine any other caufe of this fo great a difference, but the quality of the wind, that doth refresh them.’

BUT to multiply no more instances, we fhall conclude with this one, that *Charleton Island*, where Captain *James* wintered (and of which we fo often have occafion to make mention in our hiftory) though it feems by the effects to be a colder region, than even the country about *Moscow*, and perhaps as cold as *Nova Zembla* it felf; yet Captain *James*, who had feveral times occafion to take the latitude of it, (fee *James’s* voyage, pag. 61, and 81, and elfewhere) affigns it the fame elevation, and confequently the fame diftance from the pole, with *Cambridge*, whose latitude he reckons to be 51 degrees befides minutes, and whose air is very well known to be very temperate. And it is remarkable, that though this place, whose latitude is fhort of 52 degrees, was found uninhabitable by reason of the cold, (*Purchas*, pag. 569.) yet not only in Mr. *Hudson’s* voyage, the writers admonish the readers to take notice, ‘That although they ran along near the fhore, they found no great cold, which made them think, that if they had been on fhore, the place is temperate.’ *Josephus Acofta*, lib. 2. pag. 111, 112. And yet in this place they reckon themselves to have reached the 78th degree of latitude: and our recenter navigations inform us, that feveral parts of *Greenland*, to which this newly-mentioned coaft belonged, are well enough inhabited: and one of our Englifh navigators affures us, that the true height of *Puffozera* in *Ruffia* is no lefs than 68 degrees and a half, if not more, and yet that is a town not only well inhabited, but of great trade. But in *Hudson’s* voyage I find what is more ftrange, that under the 81ft degree of latitude, beyond which they difcovered land very far off, but (beyond which none is thought to have actually failed towards the pole) ‘they found it during the whole day clear weather, with little wind, and reafonably warm.’ *Purchas*, pag. 571. And beyond 80 degrees, they not only found a ftream, or two of fresh water, ‘but found it hot on the fhore, and drank water to cool their thirst, which they alfo commended.’

II. THE next observable I am to propose about the coldness of the air, is this;
 ' That the degrees both of heat and cold in the air may be much greater in the same
 ' climate, and the same place, at several seasons of the year, or even at several times
 ' of the same day, than most men would believe.'

FOR the proof of this proposition, we shall subjoin two sorts of testimonies, of travellers, and navigators; the former shewing, that in countries, where it is very cold in winter, it may nevertheless be hot in summer; and the latter manifesting, that even on the same day, as well as in the same place, the heat and cold, that succeeded one another, may be one of them sensible, though the other were extreme, or may perhaps be both of them considerable.

To make this good, we shall produce the following testimonies.

1. Dr. *Giles Fletcher*, English ambassador to the *Muscovian* emperor, in his treatise of *Russia*, and the adjoining regions, has this memorable passage to our present purpose: ' The whole country (says he, *pag.* 414.) differeth very much from itself, by reason of the year; so that a man would marvel to see the great alteration and difference betwixt the winters and summers in *Russia*. The whole country in the winter lieth under snow, which falleth continually, and is sometime of a yard or two thick, but greater towards the north; the rivers and other waters are all frozen up, a yard or more thick, how swift or broad soever they be; and this continueth commonly for five months, to wit, from the beginning of *November*, till towards the end of *March*; what time the snow beginneth to melt, so that it would breed a frost in a man to look abroad at that time, and see the winter's face of that country.' And a little after he adds, *Purchas*, 415. ' And yet in the summer time you shall see such a new hue and face of a country, the woods (which for the most part are all of fir and birch) so fresh, and so sweet; the pastures and meadows so green, and well grown (and that upon the fudden) such variety of flowers, such noise of birds (especially of nightingales, that seem to be more loud, and of a more variable note, than in other countries) that a man shall not lightly travel in a more pleasant country.' And some lines after, ' As the winter exceedeth in cold, so the summer inclineth to over-much heat, especially in the months of *June*, *July*, and *August*, being much warmer than the summer air in *England*.'

Voyage de
Moscovie
& de Perse,
livre 3. p.
m. 117,
218, 219.

ALMOST like things have been much more recently affirmed by the learned *Olearius*, secretary to the Duke of *Holstein*'s embassy into *Russia*, and now *Bibliothecarius* to the present Prince of *Holstein*. And an acquaintance of mine, who, after having lived in *Italy*, passed a summer in *Russia*, assured me, that he scarce in *Italy*, did ever eat better melons, than some, which he had eaten at *Moscow*, of a strange bigness; which bears witness to that almost incredible relation of *Olearius*, who (after having much praised their goodness at *Moscow*) affirms, that he there met with melons of 40 pound weight, of which he there teaches the culture. (*pag.* 119.)

AT the royal city of *China*, *Pequin*, which scarce exceeding the 42d degree of latitude, one would expect, that as the summer is very warm, so the winter should be very mild, as it is observed to be in divers places of *Spain*, *Italy* and *Greece*, that have the same, or a more northern latitude: and yet the learned Jesuit *Martinius*, who lived many years in *China*, assures us, that usually for four whole months together all the rivers are so hard frozen, that not only all ships are closed, and kept immoveable by the ice, but that also horses, waggons, and even the heaviest carriages do securely pass over the ice. Concerning which he adds this strange circumstance, that it is usually made in one day, though to its dissolution it require many.

Prosper Alpinus, in his learned treatise *de medicina Ægyptiorum*, lib. 1. cap. 6. tells us, that at *Grand Cairo*, where he practised physick, though that famous metropolis of *Ægypt* be distant six degrees from the tropick of *Cancer*, yet the air, which in summer is almost insupportably hot, in winter is sometimes very considerably cold; adding, that there is not any sort of diseases, that proceed (as he is pleased to speak) from distillations from the head, to which the people are not there subject. To these instances we shall annex but two more, but those remarkable ones.

THE first is mentioned by *Purchas*, as communicated to him by an eye-witness, in these words: ‘ This I thought good at our parting to advertise thee, that Mr. *Hobey* hath affirmed to me, touching the diversity of weather in *Greenland*, that one day it hath been so cold (the wind blowing out of some quarter) that they could scarce handle the frozen sails; another day so hot, that the pitch melted off the ship, so that hardly they could keep their cloths from pollution: yea, he hath seen at midnight tobacco lighted or fired by the sun-beams with a glass.’ The other example, I am to produce, is no less remarkable; namely, that in the often mentioned *Charleton Island*, where that winter was as sharp, perhaps, as any known place of the habitable world, Captain *James* his journal gives us this account of the weather: ‘ In June the sixteenth (says he, pag. 81.) was wondrous hot, with some thunder and lightning, so that our men did go into the ponds ashore to swim, and cool themselves; yet was the water very cold still. Here had lately appeared divers sorts of flies, as butterflies, butchers-flies, horse-flies, and such an infinite abundance of blood-thirsty muskitoes, that we were more tormented with them, than ever we were with the cold weather. These (I think) lie dead in the old rotten wood all the winter, and in summer they revive again. Here be likewise infinite companies of ants, and frogs in the ponds upon the land.’

THUS we see, what difference there may be in the same place betwixt the temperature of the air in the winter and summer. We shall now add, what may appear more strange, that there may be very great disparities in the heat and coldness of the air, not only in the same place, but within the compass of the same day.

THE lately mentioned *Alpinus* affords me an example to this purpose in *Ægypt* it self, where one would expect a much more uniform heat. *Hyeme* (says he, pag. 9.) *nocturnus aer admodum frigidus observatur, qui oborto sole paulo post parum incalescit, in meridieque plurimum; adveniente vere nocte rursum in frigidum permutatur, ita, at aer ille valde inequalis sit dicendus, ab ipsiusque illa inequalitate plurimi morbi originem ducunt atque generatur, qui eo tempore per urbem vagantur.*

THE learned *Olearius* relating how he travelled with the ambassadors, whose secretary he was, over a branch of mount *Taurus*, takes notice, that it being after the middle of *June*, the air of that hot region of *Persia* obliged them only to travel by night, and yet the nocturnal cold was so great, that they were all benumbed with it, inasmuch, that they were hardly able to alight from their horses; adding, that the sudden change from an extreme cold to the excessive heat, they were again exposed to the next day, cast no less than 15 of their company into strong burning fevers at once. (Which brought into my mind the complaint of good *Jacob*, who, though he lived in an eastern country, when he had said, *that in the day the drought consumed him*, adds, *and the frost by night.*)

AND the same curious traveller mentions, that in another country in *Persia*, called *Faclu*, notwithstanding the heat of the region (at the end of *March*, at which time they passed that way) they saw and felt in one night, which they were forced to

pass without their tents, both lightning, and thunders, and winds, and rain, and snow, and ice.

WE will conclude with a remarkable instance, afforded us by the journal of the English, that wintered at *Charleton Island*. 'The season here in this climate (says the often quoted author of the voyage) is most unnatural; for in the day-time it will be extreme hot, yea, not endurable in the sun; which is, by reason, that it is a sandy country. In the night again, it will freeze an inch thick in the ponds, and in the tubs about, and in our house, and all this towards the latter end of June.'

III. THE third observable I intended to take notice of about the coldness of the air, may be comprized in this proposition, 'That in many places the temperature of the air, as to cold and heat, seems not to depend so much upon the elevation of the pole, as upon the nature and circumstances of the winds, that blow there.'

It would require a very long discourse to treat in this place of winds in general, and much more to examine the several causes of winds, that are assigned by several authors; and therefore when I have once given this intimation, that divers of these opinions may be more easily reconciled, than the maintainers of them seem to have thought, to the truth, if not to one another; the causes, that may produce wind, being so various, that many of those proposed may each of them in some cases be true, though none of them in all cases be sufficient: having hinted this, I say, it may suffice, on this occasion, to subjoin three or four observations, to prove and illustrate the matter of fact delivered in the proposition.

AND first, it is a known observation in these parts of the world, that northerly and north-easterly winds do at all times of the year bring cold along with them, and commonly, if it be winter, frost. And here in *England* I have sometimes wondered at the power of the winds, to bring not only sudden frosts, but sudden thaws, when the frost was expected to be settled and durable; which yet seems to hold commonly, but not without exception. For during one of the considerablest fits of frost and snow, that I have taken notice of in *England*, I remember, that I observed (not without some wonder) that the wind was many days * southerly; unless it may be said, that this southerly wind was but the return of a stream of northerly wind, which had blown for many days before, and might by some obstacles, and agents, not here to be inquired after, be made to wheel about, or recoil hither, before it had lost the greatest portion of the refrigerating corpuscles it consisted of before.

THE formerly mentioned *Prosper Alpinus* attributes strange things to the northerly wind, that blows in *Egypt*, as to the cooling and refreshing the air, in spite of the violent heats, that would otherwise be intolerable. And many in † *Egypt* ascribe to the *Ætesian* winds that almost miraculous ceasing of the plague at *Grand Cairo*, of which we elsewhere speak. (*Ibid. lib. 1. cap. 6.*) *Dominatur autem aër* (says he) *summe calidus, ipse cæli, ut dictum est, ratione, quod hæc civitas à Tropico Cancræ tantum 6. gradibus distet. Quâ brevi intercapedine dum sol ad illum accedit Tropicum, & illorum Zenith sit propinquior, aër ille valde incalescit, & nisi Ætesæ venti*

* The weather was snowy and foggy, freezing our rigging, and making every thing so slippery, that a man can scarce stand. And all this with the wind southerly, says Captain *James*, (pag. 104.) in his journal, the 26th of *August*.

† *Ab his ventis aërem alteratum, esse causam, cur pestis illa dissolvatur, multi illorum affirmant. Quod etiam non videtur penitus à veritate alienum, quando id multis etiam rationibus nobis persuaderi possit, imprimisque, &c.* *Prosper Alpin. lib. 1. De medicina Ægypt. cap. 18.*

tunc à septentrione spirarent, vehementissimus, & qui vix à nostris perferri possit, caloris æstus sentiretur.

Advenæ nostri iis provenientiibus ad subterranea loca confugiunt, in quibus morantur, quousque ille ventorum ardor residerit atque cessaverit. Conjunxit hæc incommoda Deus optimus cum aliis quibusdam bonis, nam ubi calidissimi illi venti contiguere, statim à septentrione flare alii incipiunt, qui subitaneum inflammatis atque laxatis corporibus solatium præstant. Si enim illi diu perseveraverint, nemo in eâ regione vivere possit. Ibid. lib. 1. cap. 7. pag. 11.

WHENCE winds should have this power to change the constitution of the air, and especially to bring cold along with them, is not so easy to be determined. Indeed the other qualities, and even the heat, that is observable in winds, may for the most part be probably enough derived from the qualities of the places, by which they pass. Of this we have already given an example or two in the passages lately mentioned. And it may be further confirmed by what *Acosta* says, that he himself saw in some part of the *Indies*, (namely, *Josephus Acosta*, lib. 3. cap. 9.) ‘That the iron gates were so rusted and consumed by a peculiar wind, that pressing the metal between your fingers, it would be dissolved and crumbled, as if it had been hay or parched straw.’ And this learned traveller, who seems to have taken peculiar notice of the winds, affords us, in divers places of his book, several examples to confirm what we were saying, (though he take not the nature of the regions, along which the wind blows, to be alone in all cases a sufficient cause of their qualities) of which yet we shall now mention but these two memorable passages. *Lib. 3. cap. 2. pag. 120.* ‘In a small distance (says he) you shall see in one wind many diversities. For example, the *Solanus* or Eastern wind is commonly hot and troublesome in *Spain*; and in *Murcia*, it is the coldest and healthfullest that is, for that it passeth by the orchards, and that large champion, which we see very fresh. In *Cartbagenà*, which is not far from thence, the same wind is troublesome and unwholesome. The Meridional, (which they of the ocean call South, and those of the Mediterranean sea, *Mezzo Giorno*) commonly is rainy, and boisterous, and in the same city, whereof I speak, it is wholesome and pleasant.’ And in his description of *Peru*, lib. 3. cap. 3. speaking of the South and South-west, he affirms, that this wind yet in this region is marvellous pleasing.

BUT though, as we were saying, many other qualities of winds may be deduced from the nature and condition of the places, by which they pass; and though the heat also, which *Prosper Alpinus* (as we lately took notice) attributes to the southerly winds, that blow in *Egypt*, may be probably ascribed to the heated exhalations and vapours they bring from the southern and parched regions they blow over; yet whence the great coldness of northerly and easterly winds should come, may be scrupled at by many of the modern philosophers, who, with divers Cartesians, will not admit, that there are any corpuscles of cold.

AND possibly I could, about these matters, propose some other difficulties, not so easy to be resolved. But not being now to discuss the hypothesis about cold, I think it will be more proper in this place, instead of entering upon disputes and speculations, to subjoin an experiment, that I made, to give some light about this matter.

CONSIDERING then, that I had not met with any trial of the nature of that I am about to mention, and that such a trial might possibly prove lucriforous, I caused a pretty large pair of ordinary bellows to be kept a good while in the room, where the experiment was to be made, that it might receive the temperature of the air in that chamber: then placing upon a board one of those flat-bottomed weather-glasses, that

I elsewhere described to contain a moveable drop of pendulous water, blowing at several times with intermissions upon the bubble or lower end of the weather-glass, though the wind blown against my hand were, as to sense, very manifestly cold, yet it did not cool the air included in the bubble, but rather a little warmed it, as appeared by a small, but sensible, ascension of the pendulous drop each time, that, after some interposed rest, the lower part of the glass was blown upon, which seemed to proceed from some small alteration towards warmth, that the air received by its stay (though short) in the bellows, as seemed deducible from hence, that if by closely covering the clack, the matter were so ordered, that the air, that should come into the bellows, must come in all at the nose: if this nose being held very near the bubble of the weather-glass, the air were, by opening the bellows, suddenly drawn in, that stream or air of wind coming from a part of the window where the air was a little cooler than that, which was wont to come out of the bellows, would not, as the other, make the pendulous drop rise, but rather the contrary.

THIS done, we proceeded to shew by experiment, that though a wind were nothing but a stream of air, yet in its passage it might acquire a considerable coldness distinct from that, which it has by virtue of its motion; though upon the score of that, we see, that air moved by a fan, or (as in our newly-mentioned trial) by a pair of bellows, might, to our touch, feel cold; nor did we forbear to expect a good event of our trial, upon the doubt, that may be raised, whether there be frigorifick corpuscles or no. For whatever become of that question, I thought I might expect, that whether or no ice emit corpuscles, that are universally frigorifick, yet the air, being, either by them, or upon what account soever, highly refrigerated, the corpuscles, that compose this cold air, being most of them driven on before it by the wind, that meets them in its way, will, in a sense, prove frigorifick, in regard of a less cold body, which they shall happen to be blown upon; and accordingly, having provided a ridge-tile inverted, and half filled the cavity, which looked upwards, with a mixture of ice and salt; and having likewise put the iron pipe of the bellows upon that mixture, and then covered it with more of the same, that so the pipe being surrounded, as far as conveniently it could be, with ice and salt, the air contained in it might thereby be highly refrigerated; I found, that blowing wind out of the bellows upon my hand, that wind felt much more cold than that, which had been before blown upon my hand out of the same bellows, before the frigefactive mixture was applied to it. But for fear my sense of feeling should deceive me, I caused a weather-glass, made after the common manner, but with a more slender pipe, to be so placed, that the nose of the bellows (which, together with the tile and ice, was upheld with a frame) lay in a level with the bubble of the thermometer; and then blowing the refrigerated air of the bellows upon the globular part of the glass, I saw the water in the cylindrical part and shank manifestly ascend, as it was wont to do upon the refrigeration of the included air: and as this ascension of the liquor continued, during three or four blasts of the bellows, so, upon the cessation of the artificial wind, the water subsided by degrees again, till by fresh blasts it was made to ascend. Lastly, having repeated this experiment, we thought fit to try, how much the air, refrigerated immediately by the frigorifick mixture, would produce a colder wind than the former; and accordingly drawing back the nose of the bellows, that the air, that should be blown out, might pass along the cavity left in the frigorifick mixture by the iron pipe (of the bellows) which we had withdrawn, the wind was manifestly more cold than before, and had a greater operation on the weather-glass, it was blown upon.

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THIS experiment, if carried on, and prosecuted, may possibly prove luciferous; but I will not take upon me here to determine, whether all cold winds must necessarily be made so by frigorifick corpuscles properly so called: since I have sometimes suspected, that some winds may be cold, only by consisting of, or driving before them those higher parts of the air, that, by reason of the languid reflection of the sun-beams, in that upper (or perhaps arctic) region of the air, are for the most part very cold. For it may be observed, that rains oftentimes very much and suddenly refrigerate the lower air, when no wind, but what the clouds and rain make, accompanies them, as if they brought down store of cold air with them from that upper region; which *Acosta*, and one I conversed with, that visited far higher mountains than the *Alps*, affirm to be in some places (for I am not satisfied, that it is so every where) exceeding cold, both in hot climates, and in hot seasons of the year. And I observe that the *Hollanders* do, in more places than one or two, mention the northerly and north-easterly winds, to be those, that brought them the prodigious colds they met with, though in *Nova Zembla*, where they were exposed to them, be so northwards, that it lies within 16 or 17 degrees of the pole itself. This being a bare suspicion, it may suffice to have touched it. But I shall subjoin two or three instances on the occasion of our proposition, concerning the influence of the winds upon the air, and to shew more particularly, that even cold winds receive not always their qualities so much from the quarter, whence they blow, as from the regions, over which they blow: I shall therefore begin with what is delivered by *Mr. Wood*, in his *New England's Prospect*, part I. chap. 2. 'Whereas in *England* (says he) most of the cold winds and weathers come from the sea, and those situations are counted most unwholesome, that are near the sea-coast; in that country it is not so, but otherwise.' And having added, as his reason, that the 'north-east wind, coming from the sea, produces warm weather, melting the snow, and thawing the ground;' he subjoins, 'only the North-west wind coming over the land, is the cause of extreme cold weather, being always accompanied with deep snows, and bitter frosts; &c.' To which passages we shall add only one out of *Captain James*, as being considerable to our present purpose. *Captain James's voyage*, page 52, 53. 'The winds (says he) since we came hither, have been very variable and unconstant; and till within this fortnight, the southerly wind was coldest. The reason I conceive to be, for that it did blow from the main land, which was all covered with snow, and for that the North winds came out of the great bay, which hitherto was open.'

T I T L E XIX.

Of the strange effects of Cold.

I. **T**O enumerate and prosecute all the several effects of cold, being the chief work of the whole book, it is not to be expected, that they should be particularly treated of in this one section of it, wherein I shall therefore confine myself to mention only those effects of cold, that are not familiar, but seem to have in them something of wonderful; nor must I take notice of all them neither, lest I should be guilty of useless repetitions, but only of them, which either are not at all, or are but incidentally or transiently delivered in the foregoing sections. Nor is it to be expected, that I should pawn my credit for the truth of every one of the relations I am about to subjoin. For if they had not something of extraordinary, and, consequently, that may beget some diffidence in wary men, they would not be proper for the title of this section: and most of them, that they may be fit to be placed here, must be the effects
of

of such extreme degrees of cold, that I cannot, in this temperate climate of ours, examine the truth of them by my own trials : so that all I can do, is to make choice of such relations, as are almost all of them delivered by the relators, as upon their own knowledge. And even this may perchance not only gratify and excite the curiosity of some, who are pleased with no things so much, as with those, that have somewhat in them of prodigy ; and (which is more considerable) their narratives may afford the ingenious such strange phænomena, that the explication of them may serve both to exercise their wits, and try their hypothesis.

2. It seems not necessary, in the marshalling these observations, to be scrupulous about method ; but yet to avoid confusion, we shall first mention the effects of cold, as to those four great bodies of that part of the sublunary world we live in, that are commonly reputed elements ; and thence we will proceed to take notice of the effects of cold upon some other inanimate bodies, and, for an instance of its operation on living creatures, upon men.

OF the power of cold, either to straiten the sphere of activity of fire, or to hinder its wonted effects, the chief examples I have met with are recorded, partly by the *Dutch* in *Nova Zembla*, and partly by Captain *James*, when he wintered in *Charleton Island*. These *Hollanders* in one place speak thus ; ‘ The twentieth it was fair and still weather, the wind easterly, then we washed our sheets, but it was so cold, that when we had washed and rung them, they presently froze so stiff, that although we laid them by a great fire, the side that laid next the fire thawed, but the other side was hard frozen, &c.’ Elsewhere thus : ‘ We were in great fear, that if the extremity of the cold grew to be more and more, we should all die there with cold : for what fire soever we made, it would not warm us.’ And because it were tedious to transcribe all, that their journals afford us to our present purpose, we will conclude with this passage : ‘ Hereby we were so fast shut up into the house, as if we had been prisoners ; and it was so extreme cold, that the fire almost cast no heat, for as we put our feet to the fire, we burnt our hose before we could feel the heat, so that we had work enough to do to patch our hose ; and, which is more, if we had not sooner smelt than felt them, we should have burnt them ere we had known it.’ Though Captain *James* wintered in a country many degrees remoter from the pole, than *Nova Zembla*, yet in one place he gives us this account of the cold’s power to restrain or oppose the action of fire : (Captain *James*, p. 65.) ‘ The cook’s tubs, wherein he did water his meat, standing about a yard from the fire, and which he did all day ply with melted snow water, yet in the night season, while he slept but one watch, would they be firm frozen to the very bottom. And therefore was he fain to water his meat in a brass kettle, close adjoining to the fire ; and I have many times both seen and felt, by putting my hand into it, that side, which was next the fire, was very warm, and the other an inch frozen. I leave the rest to our cook, who will almost speak miracles of the cold.’

THUS far our English navigator, whose relation, compared with those of the *Hollanders*, makes me not so much wonder, as I once did, that men should relate to *Marcus Polus*, that there is a certain plain in *Tartary*, situated between some of the highest mountains in the world, ‘ where, if fire be kindled, it is not so bright, nor so effectual to boil any thing, as in other places.’ (*Purchas*, lib. 1. cap. 4. pag. 74.) For so *Purchas* renders that passage ; whence occasion has been taken to impute to *Marcus Polus*, a writer not always half so fabulous, as many think him, that he affirmed, that there was a country in *Tartary*, where fire could not be kindled.

Purchas,
lib. 3, cap.
5. sect. 2.
pag. 495.

4. AND as for the other newly mentioned relations of seamen and travellers, though to us that live in *England*, they cannot but seem very strange; yet I am kept from rejecting them as utterly incredible, by considering, that ice and snow having before their congelation been water, must in probability owe their coldness to that which reigned in the air: so that if in any place nature has, either so plentifully stocked the air itself with frigorifick exhalations, or other corpuscles (if we will admit any such, or have upon any other account rendered it as cold, as it can make ice and snow to be, even here amongst us; I know not, why the northerness of the climate, and perhaps some saline exhalations from the earth and sea, may not there diffuse through the air a cold superior to that, which by small quantities of ice (or snow) and salt can at a small distance be produced here. And this cold is so intense, that by pouring some water on a joint-stool, and placing on it a silver tankard, or other convenient vessel, we may, as experience has assured me, with beaten ice (or snow) and salt, and a little water (which is added to hasten the solution of the other) nimbly stirred together in the pot, make the mixture freeze the external water quite through the tankard; and they may be by this way so hard frozen together, as that by lifting up the pot, you may lift up the joint-stool too, and that (which is the circumstance, for which I mention this) just by the fire, which in this case is unable to hinder so difficult an operation of the cold.

5. THUS much of the effects of cold, in reference to fire. What the same quality may perform upon air, we shall say but little of in this place, because we treat of those phenomena, partly in the foregoing section of the coldness of the air, and partly in other places. Only we shall not here pretermit a testimony of the learned *Olearius*, who, as an eye-witness, confirms what we elsewhere deliver of the high degree of cold, to which the air may be brought. For he tells us, 'That in *Moscow* he experimentally found that, which others left recorded in their writings, that one's spittle would be congealed before it reached the ground, and that water would freeze as it was dropping down.' (*Olear. lib. 3. p. m. 117.*)

6. OF the effects of cold upon water, we shall not need to say much in this place, since the two notablest of them being the power cold has to congeal water suddenly, and the force it has to turn vast quantities of it into solid ice; of the former I have newly given, out of *Olearius*, an example as eminent as almost any, that is to be met with; and of the latter also I have given several instances, in the section, that treats of ice: yet two or three notable instances, which we do not elsewhere mention, it will not be improper to deliver in this place.

7. THE first declares, that notwithstanding the warmth of the inside of a man's mouth, his spittle may be frozen even there. 'The 27th of *September* (they are the words of *Gerat de Veer*) it blew hard north-east, and it froze so hard, that as we put a nail into our mouths (as when men work carpenter's work, they use to do) there would ice hang thereon, when we took it out again, and made the blood follow.' (*Purchas; pag. 461.*) The like relation (if I misremember not) I have met with in a modern English navigator; and it is very little, if at all more strange, than what is affirmed by Queen *Elizabeth's* ambassador to the *Russian* emperor: 'In the extremity of winter (says Doctor *Fletcher*, speaking of *Muscovia*) if you hold a pewter dish or pot in your hand, or any other metal, except in some chamber, where their warm stoves be, your fingers will stick fast to it, and draw off the skin at the parting.'

8. THE other instance, I intend to mention, is this, that though *Macrobius*, and other learned men both ancient and modern, will not allow salt water to be con-

gealable;

geable; yet the *Dutch* at *Nova Zembla* relate even in the midst of *September* (and as the marginal note says, in a night) 'it froze two inches thick in the salt water.' (*Purchas*, pag. 491.)

9. As to the effects of violent colds upon the earth, what they would prove upon pure elementary earth (if any such there be) I can but conjecture; but as for that impure or mingled earth, which we commonly tread on, the effects of extreme cold upon that may be very notable. For *Olearius* relates, 'that in the year 1634, the cold was so bitter at *Moscow*, that in the great market-place he saw the ground opened by it so, that there was made a cleft of many yards long, and a foot broad.' [And the present great duke of *Muscovy*'s physician being asked by me concerning the truth of such relations, answered me, that he himself had in those parts seen the ground reduced by the cold, to gape so wide, that a child's head might well have been put into the cleft.]

10. It is somewhat strange, that the violent heat of summer, and the extreme cold of winter should both of them be able to produce in the ground the like effects: but whether to make these gaping chinks, that we have been speaking of, the surface of the ground exposed to the air, being first frozen, is afterwards broken by the expansive force of the moist earth underneath, to which the cold at length pierces, and congealing it, makes it swell, and heave, and so burst or cleave the hard and frozen crust of the ground, which cannot sufficiently yield to it; whether this (I say) may produce the clefts we were speaking of, or whether they must be derived from some other cause, not having yet made the experiments I thought upon, to clear the matter one way or other, I do not as yet pretend to determine, but will rather subjoin the second observation, I purposed to mention, of a strange operation of cold upon the ground; and it is afforded us by the *Dutch*, in their often quoted third voyage to *Nova Zembla*; in one place of which they tell us, 'That when they had built them a wooden house, and were going to shut themselves up in it for the winter, they made a great fire, without the house, therewith to thaw the ground, that they might so lay it, viz. the wood, about the house, that it might be the closer; but it was all lost labour, for the earth was so hard, and frozen so deep into the ground, that they could not thaw it, and it would have cost them too much wood, and therefore they were forced to leave off that labour.'

11. AFTER what we have said about the strange effects of cold, in reference to fire, air, water, and earth, we will now proceed to take notice of its effects upon confessedly compounded bodies, whether inanimate or living: but of the former sort of mixed bodies (I mean those, that have not life) it will not be necessary to say much in this section, in regard that we have in many other places, upon several occasions, had opportunities to mention already most of the particulars, that belong to that head. For we elsewhere take notice, that violent colds would freeze beer, ale, vinegar, oil, common wine, and even sack, and *Alicant* themselves. We have likewise noted, that the cold may have a notable operation upon wood, bricks, stone, vessels of glass, earth, and even pewter, and iron themselves; to which *Baribolinus*, out of *Janus Munck*'s voyage to *Greenland*, allows us to add vessels of brass (though these are not immediately broken by the cold, but by the included liquors, which it dilates) and divers strange effects of cold upon inanimate bodies, which it were here troublesome to recapitulate, may be met with dispersed in several places of the present history. Wherefore having only intimated in general, that, though many plants are preserved by a moderate cold, yet it has been observed, that most garden-plants are destroyed by excessive degrees of it, we will pass on to consider the effects of cold upon animals: of the many observations,

that

that we have met with among travellers, concerning this subject, we shall, to avoid prolixity, deliver only the considerablest, and those, that we find attested by very credible writers.

12. CAPTAIN *James*, speaking of the last of the three differences he makes of cold (namely, that, which he and his company felt in the woods) gives this account of it; (Captain *James's* voyage, p. 64.) ‘As for the last, it would be so extreme, that it was not endurable; no clothes were proof against it, no motion could resist it. It would moreover so freeze the hair of our eye-lids, that we could not see; and I verily believe, that it would have stifled a man in a very few hours.’

13. *Olearius* giving an account of the air of *Muscovy*, and especially the capital city of it, ‘The cold (says he, *Livre* 3. p. m. 117.) is there so violent, that no furs can hinder it, but sometimes men’s noses and ears, feet and hands will be frozen, and all fall off.’ He adds, that in the year 1634, when he was there, ‘they could not go 50 paces without being benumbed with cold, and in danger of losing some of their limbs.’ And yet to add that remarkable observation upon the by, the same author, near the same place, speaking of *Moscow*, and the neighbouring provinces distinguished from the rest of that vast empire, says, (*Livre* 3. 116.) ‘that the air is good and healthy, so that there one scarce ever hears of the plague, or any other epidemical diseases.’ And he adds, that for that reason, when in the year 1654, ‘the plague made havock in that great city, the thing was very surprizing, nothing like it having been seen there in the memory of man.’

14. OUR already divers times mentioned English ambassador Dr. *Fletcher*, speaking of the cold, that sometimes happens in *Russia*, witnesseth thus much of it: ‘Divers, (says he, *Purchas*, lib. 3. pag. 415.) not only that travel abroad, but in the very markets and streets of their towns, are mortally pinched, and killed withal; so that you shall see many drop down in the streets, many travellers brought into the towns, sitting dead and stiff in their sleds. Divers lose their noses, the tips of their ears, and the balls of their cheeks, their toes, feet, &c. Many times, when the winter is very hard and extreme, the bears and wolves issue by troops out of the woods, driven by hunger, and enter the villages, tearing and ravening all they can find, so that the inhabitants are fain to flee for the safeguard of their lives.’

15. To descend now to observations, that do somewhat more punctually set forth the more particular phenomena of cold, in reference to men’s bodies, take the following observation: ‘The 15th of *March* some of their men, that had been abroad to kill deer, returned so disabled with cold, which did rise up in blisters under the soles of their feet, and upon their legs, to the bigness of walnuts, that they could not recover their former estate (which was not very well) in a fortnight after.’ This may be confirmed by that passage of the *Hollanders*, where speaking of their preparing springes to take foxes, they add, (*Purchas*, pag. 497.) that ‘they did it with no small trouble; for that if they stayed long without doors, there arose blisters upon their faces and ears. We did daily find by experience (says Captain *James*, pag. 64.) that the cold in the woods would freeze our faces, or any part of our flesh, that was bare; but it was not so mortifying, &c.’

16. THE Dutch, speaking of the pains they were fain to take to dig away the snow, that covered the house, and choked up their doors, adds, (page 497.) that in that laborious work, ‘they were forced to use great speed, for they could not long

‘ endure without the house, because of the extreme cold, although they wore foxes skins about their heads, and double apparel upon their backs.’

17. THE lately mentioned Captain *James* relates, that in *Charleton* Island he was fain to cut the hair of his head short, and shave away all the hair of his face, because the icicles, that would be fastned to it, made it (as he speaks, page 56.) become intolerable.

Page 52.

18. AND he elsewhere relates, that once he and his companions, having been for a little while parted into two companies, ‘ had their faces, hair, and clothes so frozen over, that they could not know each other by their habits, nor (which is a considerable circumstance, for whose sake chiefly I mention this passage) by their voices.’

19. AND the same author gives this account of the death of the gunner of his ship, whom he calls a strong-hearted man, and who died before the end of *November*. ‘ He had (says our author) a close boarded cabin in the gun-room, which was very close indeed, and as many clothes on him as was convenient, (for we wanted no clothes) and a pan with coals of fire continually in his cabin; for all which warmth, his plaister would freeze at his wound, and his bottle of sack at his head.’

Purchas,
lib. 3. cap.
5. pag. 496.

20. ‘ THE 11th of *December* (says *Gerat de Veer*) it was fair weather, and a clear air, but very cold, which he that felt not would not believe; for our shoes froze as hard as horns upon our feet, and within they were white, so that we could not wear our shoes, but were forced to make great pattens, the upper part being sheepskins, which we put on over three or four pair of socks, and so went in them to keep our feet warm; yea, and the clothes upon our backs where white over with frost.’

Page 65.

Purchas,
page 49.

21. WHICH may be somewhat confirmed by this passage of Captain *James*: ‘ The clothes on our beds would be covered with hoar frost, which in this little habitacle was not far from the fire.’ We might add to all these this other passage of the often-mentioned *Gerat de Veer*: ‘ The 26th of *December*, it was foul weather, the wind north-west, and it was so cold, that we could not warm us, although we used all the means we could with great fires, good store of clothes, and with hot stones and billets laid upon our feet, and upon our bodies, as we lay in our cabins; but notwithstanding all this, in the morning our cabins were frozen, &c.’ But we shall not insist on such passages as this last recited, because that of the force of cold to repress and withstand the fire we have already delivered as remarkable things, as will be easily met with, in approved writers, in the former part of this present section.

22. I HAVE myself met with a knowing and very credible person, that related to me of the cold of *Russia*, where he travelled, little less strange things, than those I have mentioned out of books; and if I did not want the historian’s name, I should make small difficulty to add, that since I made a good progress in this present section, a very learned traveller (though not into cold countries) related to me, upon the occasion of what I was treating, what he affirmed to have met with in an approved history of the strange operation of the inclemency of the air upon multitudes of men at once; namely, that about the year (if he rightly remember it) 1498, an army of the Turks making an incursion into *Poland*, upon their return was surprized with such an extremity of cold and of snow, that though it were but (if he mistake not) in *November*, forty thousand of them (the whole army consisting of seventy thousand) perished through the extremity upon the place.

23. AMONGST

23. AMONGST the many relations I have met with of the fatal effects of cold in the northern countries, I took notice, not without a little wonder, as well as trouble, that I could not find, that any of the relators had the curiosity to see, what change was made in the internal parts of the bodies so destroyed, which yet were an inquiry very proper to have been made; but at length the other day an ingenious person having shewed me a book newly published in French, containing the description of a Polonian province he calls *Ukrain*, as I was skimming it over, with hopes to find some observations about cold, I lighted on a relation, which, though not such as I desired, is more than I have any where else found; and I take the more notice of it, because that though the very name of this province is scarce hitherto known to us in *England*, yet having a while after, by good chance, met with an intelligent Polonian lord, and having enquired of him, whether he had ever been in that country, he both told me, that he had been quartered there, and by his answers and relations did countenance divers particulars of it, mentioned by this French officer (named *Monsieur de Beauplan*) who lived long there. This author then, after having taken notice, that this fertile province, though but situated in the same height of the pole with *Normandy*, is oftentimes subject to excessive colds, (which circumstance I mention as a further confirmation of something of the same nature delivered in the former section) gives an account of two differing effects of this cold upon the bodies of men; the one being a peculiar kind of sickness, the other death.

24. THE first, which I remember not to have elsewhere met with, is, that sometimes, when the natural heat proves strong enough to protect the toes, and cheeks, and ears, and other parts, that are either more remote from the heart, or more tender, from a sudden mortification; yet unless nature be assisted, either by good precautions, or remedies, she cannot hinder the cold from producing in these parts cancers as painful as those, which are caused by a scalding and malignant humour; and which let me see (says my author) when I was in those countries, that cold was not less cutting nor powerful to destroy things, than the fire to consume them. He adds, that the beginning of these cancerous sores is so small, that what produces the pain scarce equals the bigness of a pea, and yet in few days, nay sometimes in few hours, it spreads so, as to destroy the whole part it invades; which he confirms by the example of two persons of his acquaintance, who in a trice lost by congelation the badges of their sex.

25. As to those, that are killed with cold, our author informs us, that they perished by two differing kinds of death. For some being not sufficiently fortified against the cold by their own internal heat, not competently armed against it by furs, inunctions, and other external means, after having had their hands and feet first seized by the cold, till they grow past feeling it there, the rest of their bodies are so invaded, that they are taken with a (kind of lethargick) drowsiness, that gives them extreme propensity to sleep; which if indulged to, they can no more awake out of, but die insensibly. And from this kind of death our author adds, that he was several times snatched by his servants, who were more accustomed to the cold, and seasonably forced him to awake out of those drowsinesses, which they knew to be most dangerous. And that sometimes the death by cold is indolent enough, the relations of some intelligent acquaintance of mine, who have been in exceeding cold countries, do confirm.

26. BUT the other way, whereby cold destroys men, is that, which is the most remarkable in our author, and though less sudden is more cruel. For he tells us, that sometimes the cold seizes men's bodies in the reins, and all about the waist (and especially horsemen underneath the armour of the back and breast) and straitens, as he

speaks, those parts so forcibly, that it freezes all the parts of the belly, especially the guts; so that though they have keen appetites, they cannot digest, or so much as retain the lightest and easiest aliments, without excepting broths themselves, but presently reject them by vomit, with unspeakable gripings and pains, and so continually complaining of their condition, and sometimes crying out, as if somebody were tearing out their bowels, they end their miserable lives, being often brought, by the violence of their torments, to the brink of madness and despair, before they come to that of the grave. And our author having seen some of these departed wretches opened, says, that they found the greatest part of their guts black, burnt up, and as it were glewed together; whence he thinks it probable, that, as their bowels came to be spoiled and gangrenated, they were forced to those complaints and exclamations; and we may add, that probably upon the same cause depended those continual vomits of what they eat or drank, the gangrene of the guts hindring the descent of excrements downwards, as it often falls out in the true *Iliaca Passio*, and the peristaltick, or the usual motion of the parts being inverted, as it also frequently happens in the same disease. There is no doubt but anatomists and physicians will think this account very imperfect, but yet I think myself beholden to the author for it, because it is not the best, but the only, that I have hitherto yet met with of this matter; though I could wish it had been much more full and particular, and that he had also opened those animals, and especially their brains, that he mentions to have been killed suddenly, and without pain, by cold. For such informations (whose want, as far as our climate will permit, I have had thoughts of supplying upon experiments of other animals) would perhaps satisfy me one way or other about a conjecture I have had, and been able to countenance by several trials upon vegetables and dead animals, about the cause of mortifications produced by excessive cold.

27. WHAT effects a violent cold may have upon the bodies of other animals than men, I scarce find at all taken notice by the writers I have met with, and what I remember upon that subject amounts to but few particulars: the French author lately quoted takes notice in general, that the cold in *Ukrain*, as the Polanders call it, is sometimes so great, as to be scarce supportable by horses, and some other tame beasts.

28. THIS same author also mentions a certain four footed-animal called *boback*, which is said to be peculiar to those parts, and hides himself under ground in the winter: and having inquired of the lately mentioned Polish nobleman concerning this beast, he told me, that being in that province he had one presented him as a rarity, upon an occasion proper enough to be mentioned here. For some of the *Poles* chancing to dig (for some purpose that I remember not) in a certain retired place, were surprized to find under ground an animal not familiar to them; and though this creature was so frozen and stiff, that they thought it be to stark dead, yet when they came to flea it for its skin, being awakened by pain, it recovered life again, and was brought as a rarity to the commander, from whom I have the relation.

29. THAT some other animals may be frozen till they are stiff, and yet recover, I shall (ere long) have occasion to observe at the close of the 21st section. And therefore I shall now add but this, that whereas it is a tradition among travellers into northern climates, that both birds and wild beasts are in icy and snowy countries ordinarily turned white, if not at all times, yet at least in the winter by the coldness of those gelid climates; I dare neither admit the position, as a thing that is true universally, nor reject it as a thing that is never so. For not now to enquire, whether whiteness proceeds from the coldness of the country, or from some settled seminary impression,

impression, or from the imagination of the females affected by the vivid whiteness of the snow, that almost all the year long is the constant object of their sight; I find of the voyages I have perused, that navigators often mention their meeting with store of white bears and foxes in *Nova Zembla*, and other very northern regions, as also their meeting sometimes with herds of white deer. And in the *Alps*, always covered with snow, good authors mention their having met with white partridges; to which purpose I remember, that when I was in *Savoy*, and the neighbouring countries, which have mountains almost perpetually capped with snow, I heard them often talk of a certain white kind of pheasants to be met with in the upper parts of the mountains, which for the excellency of their taste were accounted very great delicacies. But on the other side, the same navigators treating even of the coldest climates, seem to distinguish the white bears from others of those parts*; and as for a herd of white deer, their colour may proceed from seminal impressions, since here in *England* I have seen several deer of that colour; and though *Greenland* be by some degrees nearer to the pole than *Nova Zembla*, yet I have seen a live deer brought thence somewhat differently shaped from ours, whose skin was not white, but rather a kind of dun: and to add that upon the by, I took notice, that provident nature, to arm them against the cold, had afforded him a coat, that might have passed for a fur.

30. Yet these two things seem remarkable in favour of the efficacy of cold; the one, that in several cold countries, as particularly *Greenland*, and *Livonia*, even modern describers of them affirm †, that hares will grow white in winter, and return to their native colour in summer; and the other, that though *Charleton Island* differ not one degree in latitude from *London*, yet (as the cold is there prodigious, so) I remember, that Captain *James* somewhere takes notice of his having seen there, both divers foxes, that were pied black and white, and white partridges, though he could not catch them. (Pag. 46, and pag. 89.) But of the whiteness of animals I elsewhere treat among other subjects, that belong to the history of colours. And having already been more prolix than I intended in setting down the observations of others, I think it now time for me to resume the mention of my own experiments, divers of which, though made before others, that have been already mentioned, X or XII sections off, I thought fit to reserve for this place, both for other reasons, and because this place seems proper for experiments, that have a nearer tendency to the hinting or the examining the more general hypothesis about cold.

T I T L E XX.

Experiments touching the weight of bodies frozen and unfrozen.

1. **S**INCE divers of those ingenious men, that have of late revived and embraced the doctrine of the old Atomists, teach us, that water is turned into ice by the introduction of frigoris corpuscles, which *Democritus* of old is said to have believed to be cubical (and to which other philosophers of late have assigned other shapes indeed, but yet determinate ones) we thought fit, not so much for our own satisfaction, as for that of others, to try, whether or no a liquor by its increase of weight,

* And it is from very northern countries, that we usually receive very dark coloured furs, and the skins as well of black foxes as of white ones.

† *Lepores coloris & pellis mutatione anni tempestates sequuntur, ac hiberno tempore albis pilis vestiti, æstivis mensibus eosdem cinereos habent.* *Livonia nova descriptio*, pag. 303.

when

when frozen, would betray any substantial accession of the corpuscles of cold, which, according to the Epicurean principles, may, by reason of their smallness, pass in freely, and in vast multitudes, at the pores of other bodies, and even of glass; and which, by reason of the same smallness, must be supposed exceedingly numerous to be able to arrest the motions of such multitudes of minute corpuscles, as must go to the making up of any considerable quantity of water.

2. AND first we made a trial with eggs, of which our notes give us the following account.

3. [WE took a good pair of scales and placing them upon a frame (purposely made for such experiments, as required, that the things to be weighed should remain long in the balance) we put into one of these a couple of eggs, and having counterpoised them with brass weights, we suffered them to continue all night in a turret (built as it had been made for an observatory) that the breaking of the eggs, or any such other accidents might not hinder the success of our endeavours, (which were to try, whether the corpuscles of cold, which divers philosophers suppose to be the efficient of congelation, would make them any whit heavier :) but we were somewhat surprized, when the next morning, after a very sharp night, going up to the turret, we found (the scales and frame being in good plight) the eggs to be grown lighter by near four grains.]

THUS far the note.

4. BUT though we afterwards repeated the experiment once or twice (if not oftener) yet having been, by intervening avocations, diverted from registering the circumstances of the events, I dare not now trust my memory for any more, than that some of the circumstances seemed odd enough, but uncertain, and that I desisted from prosecuting the experiment, chiefly for this reason, that an increase of weight in exposed eggs was scarcely to be hoped for, because it seemed probable, that part of the more subtile and spirituous corpuscles contained in the egg do continually, by little and little, get away through the pores of the skin and shell; that seeming to be the reason, why eggs long kept have usually within the shell a manifest, and sometimes very considerable cavity unfilled with either yolk or white; which cavity seems to have been left by the recess of the subtile parts we have been mentioning: so that although the frigorifick atoms should by their ingress add some, not altogether insensible, weight to the egg, yet that would not, unless perhaps in the very nick of time, when the congelation is first actually made, be taken notice of, by reason of the greater decrement of weight, that proceeds from the avolation of the more subtile parts of the egg it self.

5. AND to satisfy our selves about this matter, we took four hen eggs, and counterpoised them carefully in a good pair of scales, which were suspended at a frame, that the balance might be kept unstirred in a quiet room, wherein we had placed it; and suffering it to continue there for a pretty while, we observed, that though it were winter, and though the room, wherein it stood, were destitute of a chimney, yet that scale, wherein the eggs lay, did almost grow manifestly lighter; so that it was requisite, from time to time, to take a grain out of the opposite scale, to reduce the balance to an æquilibrium. And by this means we found the eggs, after some time, to have lost eight grains of their former weight: but how much more they would have lost, if we had continued the experiment, the need we had of the scales kept us from discovering.

UPON this occasion I will add, that I used some endeavours to satisfy myself about this inquiry, *viz.* whether eggs being once actually frozen (for those mentioned in the

former note, might lose their weight before they were so) and kept in a pair of good scales fastened to a frame in some quiet place, well fenced from the sun, would by the cold of the air, in freezing weather, be kept for any considerable time, without a sensible diminution of weight: but an unexpected thaw hindered us from seeing the success of what we designed of this nature, both as to eggs, and also some other bodies: for if the experiment were very carefully tried upon a competent variety of them, it might possibly assist us to guess, especially in camphire, and some other easily exhalable bodies, what interest cold may have in suppressing or diminishing the expiration of their effluvia.

7. BUT to return to the weight of bodies frozen and unfrozen, we attempted to discover somewhat about it by several ways, according as the differing accommodations, we were furnished with, permitted. And of these trials I will mention four or five, as well of the less, as of the more accurate, as my memory or notes supply me with them.

8. ONE of the less accurate ways we always employed to try, whether ice, in which, according to the Atomists, great store of these corpuscles must be wedged, would not, upon their expulsion or recess, leave the water lighter than was the ice, was that, which follows; wherein, to hasten the experiment, we mingled a little salt. And though we foresaw, there would be a difficulty from the adhesion of the vapours of the external air to the outside of the glass we were to employ, we thought that inconvenience might be remedied by well wiping off the frost, or dew, from the outside of the glass, till it were clean and dry: the event of the trial we find succinctly set down among our notes as follows. [A single phial sealed up with ice and salt, being wiped dry, and weighed, was found to weigh four ounces four drachms and a half: when it was quite thawed, it was found to weigh somewhat more than a grain less than its former counterpoise.]

BUT more accurate and satisfactory trials about this matter, I find thus set down in one of my papers:

9. [WE took a phial more thin than those, that are commonly used, that, of the aggregate of that and the liquor, the glass might make so much the lesser part. This phial was furnished with a somewhat long neck, which at the flame of the lamp was drawn by degrees slenderer and slenderer, that being very narrow at the top, it might the more readily and conveniently be sealed, notwithstanding the waters being in it: then we almost filled it with that liquor, I say almost, because a competent space ought to be left unfilled, to allow the water, swelled by glaciation, room to expand it self. This phial, with the liquor in it, was placed in a mixture of snow and salt after our usual manner; and when the glass appeared almost full of ice, it was taken out, and nimbly closed with *Hermes's* seal. Presently after, this was weighed in a pair of very good scales, and the phial together with the contained liquor amounted to 3v. 38. gr. ̄ss. which yet was not all ice, because these things could not be done so nimbly, but that some of the ice began to thaw, before we were able to dispatch them quite. The phial thus sealed being removed, and suffered for two or three hours to thaw, when the ice was vanished, we weighed again the sealed glass in the same scales, and found that it weighed, as before; at least, if there were any difference, it seemed, to weigh a little more. But this increment, that amounted not quite to $\frac{1}{2}$ a grain, might easily be attributed to some difference in the weights and grains themselves, wherein it is not easy to find a perfect exactness, or to some little unheeded moisture, that might adhere to some part of the phial.]

10. AND because it may be wished, that as the experiment shews the weight of ice dissolved into water, to be the same with that of the solid ice; so we had tried, whether

whether the weight of water congealed into ice would be the same with that of the former fluid water, we will subjoin what immediately follows in the same paper, in these words.

11. [WE took a sealed phial, very thin, that it might be lighter, but not so large as the other, by about a third, as amounting in the lately mentioned scales but to 3iiij. 3ij. gr. 41. when we had sealed it up with the water in it. This phial we placed, as we had done the other, in a mixture of snow and salt, freezing it warily, lest being sealed it should break; then we removed it into the same scales, to try, whether it had got any weight by the supposed subingression of the atoms of cold, which many learned men take to be the efficient of congelation; but it either weighed just as before, or if there were any difference, it seemed to have lost $\frac{1}{4}$ of a grain. Being suffered to thaw, and put into the same scales again, it weighed just as much as it did when frozen, though the weights were numerically the same, and about $\frac{1}{8}$ would sway the scales, or at least be sensible upon them. But note, that I was careful this last time to wipe the outside of the glass with a linen cloth, because I have observed, according to what I elsewhere deliver, that, in case ice be any thing hastily thawed, it may produce a dew on the outside of the glass, as I suspected that even the warm air might in some measure do in this: and if it had not been for this suspicion, some adhering dew, that I was thereby enabled to detect and wipe off, before I took the phial into the scales, might easily have imposed upon us.

12. THESE trials I presume may give some satisfaction about the enquiry, for the resolving whereof I thought fit to make them.

13. BUT I was also desirous to see, whether any difference, as to weight, would be produced by freezing and thawing (if I may use those expressions in this case) iron, stone, wood, or the like solid and permanent bodies, which I intended to have exactly weighed before and after their being exposed to the air, and also after the frost was gone, (and all this against counterpoises not exposed to so great a cold) would discover any sensible alteration, as to weight, that might safely be ascribed to the cold. And though avocations, and the negligence of one, that we employed, kept us from bringing the matter to such an issue as was desired, yet the trials seemed not altogether irrational, since we have formerly made it probable (and have since met with fresh instances to confirm it) that even stones, and metals, may resent some change of texture by the operations of some degrees of cold. And indeed induced by such considerations of that kind, as seemed the least doubtful, I remember I sometime made several experiments of the weight of some metals, and stones, both before and after they had been much exposed to a more vehement cold, than would have sufficed to turn water into ice; and also after they had been, if I may so speak, thawed in a warm air. But the paper, in which we registered the events of these trials, having been mislaid, I dare not charge my memory with the particulars. Only, if I mistake not, one or two of the stones seemed to have increased in weight, after having been buried in our frigorifick mixture, which I was apt to impute to some particles of the ice resolved into water by the salt, that was mingled with it, and (being perhaps made more piercing by the saline particles associated with them) imbibed into the pores of the stone. For I remember, that having procured an experiment, that I then wanted conveniency to try myself, to be made by an ingenious person, upon a stone hard enough to bear a good polish, I was by him informed, that the stone, by having been kept a while in water, did, though it were afterwards wiped dry, discover a manifest increase of weight: and in confirmation of my conjecture, I shall add, that from a sort of stones, that are of a texture close enough to be usually polished,

polished, I did, as I expected, obtain, by distillation, (and that without a naked fire) a considerable quantity of an almost insipid liquor, which I suspected to be in good part but water soaked into the stone, for reasons, that it is not worth while here to discourse of; the cause of my mentioning these particulars being, that (I hope) they may make those, that shall hereafter try such experiments, cautious how they draw inferences from them, and may invite them to expose the bodies, they would make trial of, rather to the cold of the free air in very sharp weather, (for want of which, we ourselves could not do what we advise) than to artificial glaciations at least, unless they be so ordered, that nothing that is moist come to touch those bodies to be wrought upon.

14. But such trials as these newly mentioned, and others of the like kind, we must leave to be prosecuted by those, that are furnished with accurate scales, and leisure; for want of the latter of which, and sometimes too of the former, we were fain to give over the pursuit of them: which troubled us the less, because those made with the sealed phials were diligently made; and as for divers others, we made them, as we were saying, more to be able to gratify others, than to satisfy ourselves; because though in case there should unquestionably appear some sensible increase or decrement of weight upon that, which the Atomists would call the *accession or expiration* of frigorifick corpuscles, it would afford a plausible argument in favour of the Epicurean doctrine, about the generation of ice: yet if no such change of weight should be found upon the freezing or the thawing of the water, or any other body, I doubt whether it may, on the contrary, be safely concluded, that the Atomists theory of cold is false. For possibly they may pretend, that the atoms of cold may not have either gravity or levity, or any more than the steams of electrical bodies, or the effluvia of the load-stone. Nay, though we should admit the frigorifick corpuscles not to be altogether devoid of gravity, it may yet be said, that when they invade the body they freeze, they expel thence some other pre-existent atoms, that may also have some little weight; and that the frigorifick corpuscles, that fly, or are driven away, may be succeeded by some such, when bodies come to be thawed. But of this no more at present.

Appendix to the XXth Title.

THE experiments, we recorded in the foregoing section, may perchance in this regard prove more useful than I was aware of, that they may keep men from being misled by the contrary accounts, that I find to have been given of the weight of ice, and water, by no obscure writers. For, to spare one of the famousst of the ancients, *Helmont*, in the treatise he calls *Gass Aquæ*, where he gives an account of the congelation of water; which I confess to be unintelligible enough to me, and where he is pleased to ascribe to I know not what extenuation of part of the sulphur he supposes to be in water, that levity of ice, which the bubbles, it contains, afford us an intelligible and ready account of, delivers very positively this experiment. *Imple* (says he, *Num. 35.*) *lagenam vitream & magnam frustis glaciei, collum verò claudatur sigillo Hermetis, id est, per vitri ibidem liquationem: ponatur hæc tum lagena in bilance, adjecto pondere in oppositum, & videbis, quod propemodum octava sui parte aqua post resolutam glaciem erit ponderosior seipsa glacie. Quod cum millesies ex eadem aqua fieri possit, &c.* Thus far *Helmont*, who in case he take *lagena vitrea* in the ordinary acception of the word, would have made us some amends for this erroneous account, if he had taught us the way, how he could seal such a broad vessel, as a glass flaggon, hermetically. But what has been delivered in the foregoing section, will sufficiently shew, what is to be thought of this experiment of *Helmont*. And for further con-

firmation, we have several times weighed ice frozen, and reduced to water, without finding any cause to doubt, but that *Helmont* was mistaken. And particularly upon the last trial I made of this kind, having filled a wide-mouthed glass with solid fragments of ice, together with it, amounting to a pound (of which the glass alone weighed somewhat above five ounces) I whelmed over the mouth of it another flat bottomed glass, that if any vapours should ascend, they might be condensed into drops, as in the like case I had formerly observed them to do. And this ice being thawed in a warm room, as no drops were seen to stick to the inside of the inverted glass, so the other glass being again put into the same scales, appeared almost exactly of the same weight as formerly; whereas the ice alone, that had been dissolved, amounting to much above eight ounces, according to *Helmont's* proportion, the weights should have been augmented by a whole ounce at least: and I make little doubt, but that if the experiment had been tried in greater quantities of ice, the event would have been very little, if at all different. But I purposely chose, in the statical experiments about cold, to make my trials in no greater quantities of matter than I have done, because it is very difficult to get scales strong enough to weigh, without being injured, much greater weights, and yet be accurate enough to discover truly such small differences, as are fit to be taken notice of in such experiments. But to return to *Helmont*: Notwithstanding all that we have said against what he delivers about the weight of ice, yet because I take this inquisitive chymist to have been, in spite of all his extravagancies, a benefactor to experimental learning, I am willing to suggest on his behalf, that possibly much of the additional weight he ascribes to the resolved ice, may have proceeded from that which would not have been taken notice of by an ordinary experimenter. For (as I not long since intimated) I have (sometimes purposely, and sometimes by chance) by thawing ice in closed vessels somewhat hastily, produced a copious dew on the outside of the vessels; which dew, as being made by the condensed vapours of the ambient air, ought to be wiped off, before the vessel be put into the scales to weigh the melted ice: and is possible also, that *Helmont* may have erred in the manner of weighing his *Lagena*, whatever he mean by it; it being usual even for learned men, that are not versed in statics, to mistake in experiments, which require, that things be skilfully and nicely weighed. How far this excuse may be applied to a late * commentator upon *Aristotle's* meteors, who says, he tried, that water frozen is heavier than unfrozen; being a stranger to that author's writings, I shall not consider: only whereas *Helmont* and he seem to agree very little in their affirmations, it will be perhaps more difficult to accord them, than to determine, by the help of our formerly registered experiments, what may be thought of both their relations.

YET I shall add on this occasion, that if I had not devised the abovementioned way of freezing water by art in hermetically sealed glasses, I should have found it difficult to reduce, what is affirmed by *Manelphus*, which I then dreamt not of, to an accurate experiment: for though I had employed a sealed glass, (which I have not heard, that he or any other has yet made use of to that purpose) yet if I had in that vessel exposed the water to be frozen the common way, it is odds (though it be not absolutely certain) that the water beginning, as it is wont, to congeal at the top, the expansion of the subsequently freezing water would break the glass, and so spoil the experiment. And for the same reason I have sometimes in vain attempted to examine the weight of water frozen by nature, according to her wonted method in open

* — Hinc gelidam congelatamque aquam graviorem esse non congelata expertus est Jo. Manelphus, Com. in 4. Meteor. Aristot. inquit Tho. Bartholinus de Nivis usu, cap. 12.

phials. And if, instead of glasses, you make use of strong earthen vessels, there is danger, that something may be imbibed, or adhere to the porous vessel, and increase the weight; and by some such way, or by some mistake in weighing, it is very probable *Manelphus* may have been deceived: which I am the more inclined to think, if we suppose him a sincere writer, not only because of some things I have taken notice of, about congelations made in earthen vessels, but because, when I have, instead of an earthen, made use of a metalline pottinger, (both which sorts of vessels have in common this inconvenience, that their ponderousness makes them less fit for accurate scales) there appeared cause to suspect, either that our author did not use metalline vessels, or, which I rather suspect, that he wanted skill or diligence in weighing. For as I find no intimation of his having employed any peculiar or artificial sort of vessels, so, if he used such as we have newly been speaking of, and had weighed them carefully, I cannot but think, that instead of finding the ice heavier than the water it was made of, he would have rather found it lighter. For I remember, that having once exposed all night a pottinger, almost full of common water, to an exceeding sharp air, and having caused it the next morning to be brought me, when the liquor was thoroughly frozen, I found it to have lost about 50 grains (if I misremember not) of its former weight. And though this event were consonant enough to my conjectures, yet for greater certainty I repeated the experiments another frosty night with this new caution; that the pottinger and water, together with the counterpoise, were kept suspended in the scales, to be sure, that no effusion of any part of the water in carrying it abroad to the open air should be made without being taken notice of: but the next morning (somewhat late) the vessel, with the contained water now congealed, appeared to have lost about 60 grains; and with the like success the trial was reiterated once more, and that in weather so sharp, that I am not apt to think, the water exposed by *Manelphus* began to freeze sooner than ours. But the event was not unexpected; for besides that I considered, that in these kind of experiments, part of the water, notwithstanding the exceeding coldness of the air, must in all likelihood fly away before the surface of it began to be congealed, I judge it not improbable, that not only the fluid part, but even that, which was already congealed, might continually lose some of its corpuscles, and by their recess lose also somewhat of its weight. And lest these conjectures should seem too unlikely, it will not be amiss to add in favour of the first of them, that having purposely provided a large pewter box, with a cover to screw on it, and having filled it almost full of water, (I say almost, because if the vessel had been quite full, the congealing cold might have burst it) and carefully weighed the aggregate of both (which amounted to 3v. zii. gr. 11. whereof the vessel weighed $\text{3ii. 3vß. and gr. 8.}$) we exposed the water after the top of the pot was screwed on, to hinder the avolation of it, to the freezing air all night, and the next morning found it frozen from the top to the bottom, though not uniformly and perfectly, but found not one grain difference betwixt its present and its former weight. And as for the second conjecture newly proposed, though it may seem somewhat strange, yet it is confirmable by this experiment, that having placed divers lumps of solid ice in a pottinger, which together with them weighed a pound, consisting of $16\frac{2}{3}$. and having exposed these things in the same scales, wherein they were weighed, to the free air, on a very frosty night, we found the ice to have lost the next morning 24 grains of its weight; and the weather continuing so cold, that it froze hard all day long in the shade, I gave order to have it kept out of the sun in the same scales, during all that time, and a good part of the following night, and then weighing it the second time, found, that the whole decrement of weight did now amount to five grains above two drachms,

though the weight of the ice, without the pottinger, were but about seven ounces and when we had kept about 13 ounces of ice, in a very frosty night, exposed to the cold air, it had lost, as early as the next morning, a good deal above two drachms of its former weight. But these statical observations have perhaps already but too much swelled this Appendix.

TITLE XXI.

Promiscuous experiments and observations concerning cold.

1. I HOPE it will not be imagined, that I have such narrow thoughts of the subject I treat of, Cold, as to believe, that I have comprized under those few titles, prefixed to the Sections of this historical treatise, all the particulars, that I knew to belong to so comprehensive a theme; as would readily appear, if I thought it convenient to insert here the scheme of articles of inquiry, that I drew up to direct my self, what inquiries and experiments to make. But though there were divers of those heads, to which I could say so little, that I judged it improper to assign them distinct titles, because, as to some of them, I had not time and opportunity to make those trials, which, if I had not wanted those requisites, might have been made, even here in *England*; and because also, as to more of them, I conceived my self unable to produce, in this temperate climate, so strong and durable a cold, as seemed necessary to make the trials, that might be referred to them, succeed so far, as to satisfy my doubts, either affirmatively, or negatively: Though, I say, these and some other considerations kept me from increasing the number of the titles, among which I have distributed the experiments and observations, that make up the foregoing part of this treatise, yet since divers particulars have occurred to me, which though they seem not properly reducible to the foregoing titles, do yet belong to the subject and design of this treatise, I think it fit to annex them in this place, and without any other order than that, wherein they shall happen to occur to me, throw them into this one section; together with some loose experiments, and divers relations, that I have met with among navigators and authors, that have travelled into the northern climates, touching cold, not forbearing to insert promiscuously among them some few *paralipomena*, which, if they had seasonably come to my hands, or into my mind, might have had a more proper place among the foregoing sections, or have composed a title by themselves. Wherefore though the observations will not be altogether unaccompanied with experiments, yet for the reasons above intimated, much the greater part of what is to be delivered under this title, will consist of collections out of voyages, in which the strange things mentioned being such, as we cannot examine by our own trials, I can equitably be thought answerable for the truth of nothing but the citations.

2. I REMEMBER I tried, at several times, divers experiments, to discover, whether or no congelation would by constriction of the pores of bodies, or vitiating their texture, or arresting the motion of their parts, hinder them from emitting those effluvia, that we call odours; but the register of these observations, being unhappily lost in one of my late removes, I dare add but these few, wherein I have no cause to distrust my memory.

3. I DID, in the months of *December* and *January*, at several times gather differing sorts of flowers in frosty weather; but in most, when they were freshly gathered, and hastily smelt to, I could scarce perceive any sensible smell: whether it were, that the causes above hinted hindered the expiration of the odoriferous steams, or that the cold had some undiscerned influence upon the organ of smelling, which made the sense
more

more dull, or that the same cold kept the alimantal juice of the flowers from rising in such plenty, and abounding so much with spirituous parts, as was usual at the more friendly season of the year: and this seemed the more likely to be one reason of the phenomenon, because most of the flowers were flaggy, and as it were, ready to wither, and because also a primrose, that was vigorous and fresh in its kind, had an odour, that was manifestly (and it will easily be believed, that it was not strongly) sweet, and genuine.

4. I took also, about an ounce, by guess, of rose-water, and putting it into a small phial, after I had smelt to it, it was exposed to freeze in the open air; and when it began to have ice in it, I then smelt to it again, but found not the perfume considerably, if so much as manifestly abated: and lastly, having suffered it to continue in the air, that was then very sharp, 'till it was quite frozen, and discovered no liquor, when the phial was turned upside down, the ice notwithstanding was not destitute of a graceful and genuine scent, though it seemed somewhat faint; but after the ice was reduced to water again, the fragrancy appeared considerable. But on this occasion it will not be improper to subjoin this caution, that care must be had, in trials of this nature, to make one's estimate betimes; for if a man should stay too long about it, there is danger, that the warmth of one's breath and face may relax the pores, or thaw the surface of the ice, that is held near his nose, and both free and excite the corpuscles of smell, that are imprisoned there, that so instead of ice, he may smell a liquor. The reasonableness of which advertisement may be justified by an experiment, that I am about to annex. For being pretty well confirmed by the casual and unwilling observations of one of my friends, curious in making sweet water, that even liquors more easy to be spoilt than rose-water would not have their fragrancy destroyed, though perhaps impaired, nor so much as their odours for the time quite imprisoned and suppressed by congelation; and this appearing congruous to what I formerly noted of the effluvia, that may, by the decrement of weight, be gathered to issue from ice itself, I thought it worth while to try, whether stinking liquors would not be more altered by congelation, than odoriferous ones. And accordingly having procured some rain-water, that had been kept in a tub, 'till it stunk so strongly, that I could hardly endure it near my nose, I caused a pottenger fall of it to be exposed all night to a very sharp air; and examining it the next morning, when it was all turned into ice, neither I, nor some others, to whom it was offered, could perceive any stink at all in it. And having in another place, but with as stinking water, repeated the experiment, when the pottenger was the next morning brought to my bed's side, I found it to smell abominably; whereupon guessing, that this difference proceeded from some thaw made by the warmth of the room in the superficial parts of the ice, I found it to be so indeed, partly by the help of the light, which discovered a little liquor upon the ice, and partly by exposing the vessel with that liquor in it to the cold air again, by whose operations an ice was produced, that was perfectly inodorous: and I remember, that one of these parcels of ice being thawed, seemed to be less stinking than before * it had been frozen; and if I had not been diverted, I should have tried, whether this ice, that did not omit odours, would emit, like other ice, effluvia, discoverable by the scales: for whether the ice would

* If it had not been for the negligence or mistake of one, that I ordered in my absence, to freeze and thaw the same water, divers times one after another, I might have added the success of that experiment, which I was sorry to miss of, because it might possibly have afforded an useful hint about a way to correct stinking waters, in some climates or season.

lose of its weight, which seemed the more probable, or would not, the event may afford a not inconsiderable hint.

5. IT is a thing not only remarkable, but scarce credible, that though the cold has such strange and tragical effects at *Moscow*, and elsewhere in cold countries, as we have formerly mentioned, especially a little after the beginning of the 18th and somewhere in the 19th section; yet this happens to the Russians and Livonians themselves, who, not only by living in such a country, must be accustomed to bitter colds, but who, to harden themselves to the cold, have used themselves, and thereby brought themselves to be able to pass to a great degree of cold, from no less a degree of heat, without any visible prejudice to their healths. For I remember, that having inquired of a virtuoso of unquestionable credit, whether the report of our merchants, concerning this strange custom of the Muscovites and Livonians, were certainly true, he assured me, that it was so, at least as to the Livonians, among whom, being in their country, he had known it practised. And the same was affirmed to me by an ingenious person, a doctor of divinity, that had occasion some years since to make a journey to *Moscow*. And the tradition is abundantly confirmed by *Olearius*, whose testimony we shall subjoin, because this seems one of the eminentest, and least credible instances, that we have yet met with of the strange power, that custom may have, even upon the bodies of men. 'It is a wonderful thing, says he, to see how far those bodies (speaking of the Russians, that are accustomed and hardened to the cold) can endure heat, and how when it makes them ready to faint, they go out of their stoves stark naked, both men and women, and cast themselves into cold water, or cause it to be poured upon their bodies, and even in winter wallow in the snow.' To which passage our author adds, from his own observation, particular examples of the truth of what he delivers.

Olearius,
livre 3.
pag. 168.

6. I HAD several years since, the curiosity to try, whether there were any truth in that tradition, which is confidently affirmed, (and experience by some is pretended for it) that the beams of the moon are cold; but though I were not able to find any such matter, either by the united beams of the moon, or by the same beams concentrated by such burning-glasses as I then had; yet having some years after furnished my self with a large and extraordinary good metalline concave, I resolved to try whether those beams were not only devoid of cold, but also somewhat warmish, since they are the sun-beams, though reflected from the moon. And we see, that his beams, though reflected from glasses not shaped for burning, may yet produce some not insensible degree of warmth. But notwithstanding my care to make my trials in clear weather, when the moon was about the full, and, if I misremember not, with a weather-glass, I could not perceive by any concentration of the lunar beams, no not upon a black object, that her light did produce any sensible degree, either of cold or heat; but perhaps others, with very large glasses, may be more successful in their trials.

7. ON this occasion I shall add, that meeting the other day in a bookseller's shop with the works of the learned physician *Sanctorius* (whom I look upon as an inquisitive man, considering when and where he lived) a picture drew my eyes to take off an experiment, whereby he thinks to evince the light of the moon to be considerably hot; which he says, he tried by a burning-glass, through which the moon's light being cast upon the ball of a common weather-glass, the water was thereby depressed a good way, as appeared to many of his disciples, amidst whom the observation was made. But though this may invite me, when opportunity shall serve, to repeat my trials, yet I must till then suspend my assent to his conclusion. For my burning-glass was much better, than by the narrative his seems to have been; and my trials were perhaps

perhaps at least as carefully and impartially made, as his experiment, in which this may probably have imposed upon him; that performing the experiment, a company of his scholars, whilst they stood round about his thermoscope, and stooped (as in likelihood their curiosity made them to do) to see by so dim a light the event of the experiment, the unheeded warmth of their breath and bodies might, unawares to *Sanctorius*, somewhat affect the air included in the weather-glass, and by rarifying it, cause that depression of the water, which he ascribed to the moon-beams. But because this is a conjecture, I intend, if God permit, to repeat the experiment, when I shall have opportunity to do it with a more tender weather-glass, than I had by me, when I made my former observations.

To the XIth TITLE.

BY the unsuccessfulness of the former attempts made with an iron instrument, I was invited, especially being at another place, where I was unfurnished with such hollow iron balls, as are mentioned *num. 10.* to substitute the following experiment. I caused a skilful smith to take a pistol-barrel, guessed to be of about two foot in length, and of a proportionable bore; and when he had, by riveting in a piece of iron, exactly stopped the touch-hole, I caused him to fit to the nose of the barrel a screw, to go as close as well he could make it: and then having filled it to the very top with water, I caused the screw to be thrust in (which could not be done without the effusion of some of the water) as forcibly as the party I employed was able to do it, that the water, dilated by congelation, might not either drive out the screw, or get between it and the top of the barrel. And having then suspended this barrel in a perpendicular posture in the free air, in a very cold night, which then unexpectedly happened, and gave me the opportunity of making the trial, I found the next morning, that the intumescent water had thrust out a great part of the screw, notwithstanding, that, to fill up intervals, I had oiled it before; and was got out betwixt the remaining part of it, and the barrel, as appeared by some ice, that was got out, and stuck round about the screw. Wherefore, the bitter cold continuing one day longer, I did the next night cause the intervals, that might be left betwixt the male and female screws, to be filled up with melted bees wax, which I presumed would keep the screw from being turned by the water: and having in other points proceeded as formerly, I found the next morning that the screw held, as I desired, and the preceding night having been exceeding bitter, the cold had so forcibly congealed, and expanded the water, that it burst the iron barrel somewhat near the top, and made a considerable and oblique crack in it, about which a pretty quantity of ice appeared to stick; besides that, there were three or four other flaws, at some of which smaller quantities of water appeared to have got out. At the same time, that I bespoke this iron barrel of the smith, I ordered him to get me a brass one filled up after the same manner, to make the experiment the more satisfactory. But though he could not procure it, yet the success was not unwelcome, because it was manifest, that there were cracks in the iron in one place conspicuous, and in others easily discoverable, by blowing into the barrel, and putting on the outside of the suspected parts, either spittle or some fit liquor, whose agitation plainly disclosed the egress of the wind; and there appeared small cause to doubt, but that these cracks were produced by the operation of the cold; since not only the smith was a skilful man in his trade, and one, that I used to employ about instruments, and also the barrel had been sometimes kept many hours filled with water, without appearing other than very stanch: but, which is the considerablest circumstance, the night before, the frost, as I lately noted, was not able to make the water break out at any of these clefts, though it were able

to force it self a way out at the screw, in spight of all the care we had taken to make it go close. I have only this circumstance to add about this matter, that when by thawing one part of the ice, some pieces of the rest were got out of the barrel, all I took notice of appeared to be full enough of bubbles, but yet such as seemed lesser than ordinary, whether they were so by chance, or were determined to be so, by the resistance or compression, which the freezing water found upon its endeavouring to expand its self in the barrel.

Appendix to the XVIIth Title.

LONG since the writing of the foregoing section, meeting with a passage in *Bartholinus*, where he vouches *Cabeus* for the experiment of congealing water (without limiting it to any season of the year) by putting salt-petre into it, and shaking it strongly, I was thereby confirmed, that I was not mistaken, in supposing, that *Gassendus* (mentioned in the former section) did not exclude that corporal and visible nitre out of the number of the grand efficient of congelation. For *Cabeus* having published his comment upon *Aristotle's* meteors (whence this experiment is taken by *Bartholinus*) before *Gassendus* published this book, it is probable, that he as well as others borrowed the experiment from him; and *Cabeus*, as *Bartholinus* quotes him, prescribes the putting the salt-petre itself into water, which being a while put into a brisk motion, will, after some agitation, not only refrigerate that water, but bring it to a true and proper congelation.

WHEREFORE suspecting, that this relation, wherein *Bartholinus* says, he will believe him without an oath, may have given rise to the opinions and affirmations of those ingenious writers, that have since ascribed such wonderful coldness to nitre, and finding in *Bartholinus*, that *Cabeus's* proportion betwixt the nitre and the water, was that of 35 to 100, that is, almost as one to three, I thought it very well worth while to make trial of an experiment, which seemed to me little less unlikely than considerable.

I TOOK then a pound of good salt-petre, and near three pound of common water (to observe the more narrowly *Cabeus's* proportion) these being put into a large new pipkin, were kept constantly and nimbly stirred about, sometimes by me, sometimes by one or other of the domesticks relieving one another, when they were weary; but though the mixture was with a kind of broad glass spattle kept in a brisk motion, that for the most part was after the manner of a whirl-pool, and sometimes a more confused agitation, and though we kept it thus stirring for almost an hour and a half, till we saw no likelihood of effecting any thing by trying our selves any further, yet not only we could not perceive that any atom of true ice was produced; whereas, according to our authors, we might have expected a true and perfect congelation of all, or the greatest part of the water, but we did not find, that there was so much as any freezing of the vapours on the outside of the vessel; and for this reason we thought fit about the same time, to try the experiments by another kind of agitation, and mixing two ounces of salt-petre with about six of water, in a conveniently sized phial, we did several of us successively vehemently shake the phial to and fro, till we were almost tired; but neither this way was there produced the least ice within the glass, or the least congelation of the vapours of the air on the outside of it. It is true, that when so great a proportion of salt-petre began to be dissolved in the pipkin, the water had a sensible increase of coldness, which afterwards seemed to diminish, when once the nitre was dissolved; but not-to mention, that (if I much mistake not) we have observed the water to be refrigerated, when, upon the dissolution of common salt, multitudes of actually cold and solid corpuscles came to be every way dispersed through

through it; this coldness produced by the nitre was very far short of the degree requisite to congelation: for to satisfy myself, that my sense did not mis-inform me, I took a good sealed weather-glass of about ten or twelve inches long, and immersing it into the cold mixture of nitre and water, I observed the tinted spirit of wine in the stem to descend not inconsiderably; and when I perceived that degree of cold to have wrought its effect, I removed the thermoscope into a phial filled with common water; about which I had caused to be placed a mixture of beaten ice and salt, to refrigerate the contained water, in which the ball of the instrument being placed, the spirit of wine hastily descended two or three inches below that place, at which it stood, when it was removed out of the nitrous solution: and, for further satisfaction, removing the thermoscope once again into that solution, the spirit of wine in the stem was hastily impelled up, as if the bubble had been put into warm water. And, once more, the weather-glass being removed into the formerly mentioned refrigerated water, the tinted liquor began to fall down hastily again, and, within a while, subsided almost into the bubble; whereupon, to avoid injuring the instrument, we thought fit to take it out. So that, upon the whole matter, if the learned *Cabæus* were not deluded by mistaking some crystals of nitre (which I have observed easily to shoot again in water, that has been glutted with it) for true and proper ice, I cannot but wonder at his assertion, and must take the liberty to think my self warranted, by so many harmonious trials, as I have found unfavourable to the supposed supremeness of cold in salt-petre, to retain my former opinion about it, till more successful experiments withdraw me from it.

It is a received tradition, among the watermen and many others, that the rivers, if not ponds also, are frozen first at the bottom, and begin to thaw there. But though I find this opinion to be in request, not only among English watermen, but among the French too, yet I think it may be very warrantably questioned: for it is evident, in waters we expose to freeze in large vessels, that the congelations begin at the surface, where the liquor is contiguous to the air; and thence, as the cold continues to prevail, the ice increases, and thickens downwards: and therefore we see, that frogs retire themselves, in frosty weather, to the bottom of ditches, whence I have had many of them taken out, very brisk and vigorous, from under the thick ice that covered the water. And I have been informed by an observing person, that at least in some places, it is usual, in winter, for shoals of fishes to retire to those depths of the sea, if not of rivers also, where they are not to be found in summer. Besides, if rivers were frozen at the bottom, we must very frequently meet, in the emergent pieces of ice, the shapes of those irregular cavities and protuberances, that are often to be found in the uneven soils, over which rivers take their course; whereas, generally, those emergent pieces of ice are flat, as those flakes, that are generated on the surface of the water. Moreover, if even deep rivers freeze first at the bottom, why should not very many springs and wells freeze first at the bottom too: the contrary of which nevertheless is obvious to be observed. In confirmation of all which, we may make use of what we formerly noted, (in the section of the *Primum Frigidum*) about the practice of the masters of the French salt-works, who, by overflowing the banks and causeways all the winter, keep them from being spoiled by the frost; which could not be done, if the waters, they stand under, froze as well at the bottom, as at the top.

BUT, I find, that that, which deceives our watermen, is, that they often observe flakes of ice to ascend from the bottom of rivers, to the top; and indeed it often happens, that, after the hard frost has continued a while, these emergent pieces of ice do very much contribute to the freezing over of rivers. For, coming, in some of

the narrower parts of them, to be stopped by the superficial ice, that reaches on each side of the river, a good way from the banks towards the middle, those flat icy bodies are easily cemented by the violence of the cold, and, by the help of the contiguous water, to one another, and by degrees streightning, and at length choaking up the passage, they give a stop to the other flakes of ice, that either emerging from the bottom, or loosened from the banks of the river, are carried down the stream towards them; and these being also by the same cold, cemented to the rest, the river is at length quite frozen over. And the reason, why so many flakes of ice come from the bottom of the river, seems to be, that, after the water has been frozen all along near the banks, either the warmth of the sun by day, or some of those many casualties, that may perform such a thing, does by thawing the ground, or otherwise, loosen many pieces of that ice together with the earth, stones, &c. that they adhered to, from the more stable parts of the banks; and these heavy bodies do, by their weight, carry down with them the ice they are fastened to; but then the water at the bottom of the river being warm, in comparison of the air, in frosty weather, (since that even common water is so, we have manifested by experience, where we shew how much sooner ice will be dissolved in water, than thawed in air) the dispersed ice is by degrees so wrought upon, that those parts, by which it held to the stones, earth, or other heavy bodies, being resolved, the remaining ice being much lighter, bulk for bulk, than water, gets loose, and straightway emerges, and may perhaps carry up with it divers stones and clods of earth, that may yet happen to stick to it, or be inclosed in it, the sight of which persuades the waterman, that the flakes of ice were generated at the bottom of the river; whereas a large piece of ice may carry up, and support bodies of that kind, of a great bigness, in case the ice it self be proportionably great, so that the aggregate of the ice, and heavy bodies, exceed not the weight of an equal bulk of water. On which occasion I remember, that Captain *James Hall*, in a voyage extant in *Purchas*, relates, that, upon a large piece of ice in the sea, they found a great stone, which they judged to be three hundred pound weight. But, of the tradition of the watermen we shall say no more, than that this hath been discoursed, but upon no great information, though the best we could procure; so that, for further satisfaction, it were to be desired, that, either by sending down a diver, or by letting down some instrument fit to feel (if I may so speak) the bottom of rivers with, and to try, whether ice, if he met with any, be loose from, or uniformly coherent to the ground, and also bring up parcels of whatever stuff it meets with there, the matter were, by competent experiments, put out of doubt.

WE took a sealed weather-glass, furnished with spirit of wine, and though not above ten inches long in all, yet sensible enough; and, having caused a hole to be made in the cover of a box, just wide enough for the small end of the glass to be thrust in at, we inverted the thermometer, so that the ball of it rested upon the cover of a box, and the pipe pointed directly downwards. Then we placed about the ball a little beaten ice and salt, and observed, whether, according to our expectation, the tinted spirit, that reached to the middle of the pipe, or thereabouts, would be retracted upon the refrigeration of the liquor in the ball; and accordingly the spirit did in a very few minutes ascend in that short pipe above an inch higher than a mark, whereby we took notice of its former station, and would perhaps have ascended much more, if the application of the frigorifick mixture had been continued; by which, and another succeeding experiment to the same purpose, it seems that the condensation of liquors by cold, is not always affected by their proper gravity only, which ordinarily may be sufficient to make the parts fall closer together: but whether in our case,

case, the contraction be assisted by some little tenacity in the liquor, or by the spring of some little aerial, or other spirituous and elastick particles, from which the instrument was not perfectly freed, when it was sealed up, or which happened to be generated within it afterwards, will be, among other things, more properly inquired into in another place, where we may have occasion to make use of this experiment.

THERE is a famous tradition, that in *Muscovy*, and some other cold countries, it is usual out of ponds and rivers to take up good numbers of swallows inclosed in pieces of ice; and that the benumbed birds upon the thawing of the ice in a warm room, will come to themselves again, and fly about amazedly for a while, but not long survive so great and sudden a change. I have in another treatise already said somewhat about this tradition, and therefore shall now say no more of it, than these two things: first, that I since was assured by a person of honour, that is very curious, and was commanded by a (many ways) great prince to enquire out the truth of it, when he was in some of those countries, where the thing is said to be familiar enough, and that the eminentest and soberest persons he could ask affirmed the thing to be true: but, (secondly) having lately enquired about this matter of a knowing person of quality, that was born and bred in *Poland*, he answered me, that in the parts, where he lived, it was a very general and unquestionable opinion, that swallows often hid themselves all the winter under water in ponds and lakes, and sedgy places, and that the fishermen, when having broken the ice, they cast their nets for fish, to draw them up benumbed, but not dead, so that they quickly in stoves recover their wings, but seldom after that prolong their lives. But as for their being taken up in ice, he told me, he had not heard of it; though I see not, why in case they commit themselves to shallow waters, as those of ponds and sedgy places often are, a sharp lasting frost may not sometimes reach them. And therefore that, which left me the greatest scruple about this tradition, is, that this gentleman, notwithstanding his curiosity, could not affirm, that ever he himself had seen any example of the thing he related.

BUT I will take this occasion to add, that having a mind in frosty weather to try some anatomical experiments about frogs, one, that I employed breaking in a ditch some ice, that was very thick, and of which he was to bring me a quantity, found in the water, that was under the ice, good store of frogs (besides some toads) which I found to be very lively, and divers of which I kept for certain uses a good while after.

To confirm, and to add some paralipomena unto what I have delivered in the second, and in the twentieth titles, about the frost's getting into hard and solid bodies, I shall here subjoin some particulars there omitted, which I have learned partly from experiments, and partly from persons worthy of credit, whom I purposely consulted about this matter.

AND first, as to the freezing of wood, we have sometimes tried it by purposely exposing partly other wood, and partly branches cut off from growing trees, to an intense degree of cold, by which the wood seemed in one night to be for some little depth manifestly enough invaded by the frost. But a domestick of mine having a little while since had occasion to fell an old apple-tree, on a day, that had been preceded by a fortnight's bitter frost, came and informed me, that he found, that the frost had evidently pierced into the very middle of it, though it were about a foot in diameter. And an experienced artificer, whose head and hand were much employed about the building of great men's houses, told me, that he had often seen here in *England* pieces of timber itself manifestly frozen, and rendered exceeding difficult to

be sawed, the frost also appearing by evident signs to continue in the saw-dust. And therefore it will be the less strange, if in *Poland* the effects of cold upon wood be more conspicuous. For a learned native assured me, that in his country it was usual to have wood frozen so hard, that the hatchets would not cut it, but rebound from it; and that it was very usual to hear in the night a great many loud cracks, almost like the reports of pistols, of the shingles or wooden tiles, wherewith in many places they cover their houses instead of slate; and this (as I purposely asked) when the weather was dry, and excessively cold. When I likewise enquired about the thawing of wood, he told me, he had several times seen pieces of timber, which having been thoroughly frozen in the air, did, when brought into rooms, made warm by stoves, become covered with a kind of hoar frost, and made them look white, and that though his bow (which he shewed me) were very strong and tough, as being made not of wood, but horn, and other close materials, it would be so changed by the frost, that unless special care were had in the thawing of it, it would break.

THAT marl and chalk, and other less solid terrestrial concretions, will be shattered by strong and durable frosts, is observed by husbandmen, who thereby find it the better fitted to manure their land; the texture of those bodies, during whose intireness the parts most proper to feed grass and corn, are more locked up, being by congelation in great part dissolved; but that true and solid stones, wont to be employed in noble and durable buildings, should be spoiled by the frost, will perhaps to most readers seem very improbable. And therefore I shall here add what I have learned by inquiry of the ingeniousest and most experienced mason I have met with, because it may not only surprize most readers, but prove an useful observation to him. Having then enquired of this tradesman, whether he did not find, that some free stone, a name vulgarly known, would not be spoiled by the frost, he told me, that he had often observed both free stone and harder stones than that, to be exceedingly spoiled by the frost, and reduced to crack or scale off, to the blemishing and prejudice of the houses, that are built of them. But because it may be objected against this, that experience shews us, that divers of the stateliest fabricks in *England* have these stones for their chief materials, and it endure very well the inclemencies of the air; the reply may be, that the difference may not consist in the peculiar natures of the stones employed, but in the several seasons in which the same kind of stones are digged out of the quarry. For if they be digged up, when the cold weather is already come in, and employed in building the same winter, they will, upon very hard frosts, be apt to be shattered or scale; but if they be digged early in the summer, suffered to lie exposed to the sun and air, during all the heat of the summer, these seasoned stones, if I may so call them, may out-last many sharp winters unimpaired. It seems to me worth trying, whether during their insolation, if that term may be allowed me, there do not, by the operation of the heat and air upon them, exhale a certain unripe mineral, sap or moisture (whose recess may perhaps be discovered by weight) which, if it remain in the stone, may, by very piercing frosts, be congealed almost like the sap in timber-trees, and shatter the texture of the stone; which agrees well with what was told me by an understanding person, that is master of a great glass-house, of whom having purposely inquired, whether he did not find, that his great earthen pots, which are made up with as little water as is possible, and are deservedly famous for their durable texture, had not that texture altered and impaired by very piercing frosts; he assured me, that if he did not take care to keep the frost (as they speak) from getting into them, those great and solid-vessels, wherein he used to keep his glass in fusion, would, in the fire, scale or crack (and perhaps fly) and become unserviceable no less than some weeks sooner, than if they had never been impaired by the frost.

frost. And when I inquired, whether also glass itself would not be much prejudiced thereby, he affirmed to me, that oftentimes in very hard frosts many glasses, that had continued entire for many weeks (for that circumstance I was solicitous to ask about) would as it were of their own accord crack with loud noises. But whatever prove to be the issue of such trials, it will not be amiss to confirm the phenomenon itself, by the testimony of an illiterate but very experienced French author, who, on a certain occasion, tells us, (as I also take notice in another * treatise) 'That he knows the stones of the mountains of *Ardenne* (famous enough in *France*) are harder than marble, and yet the inhabitants of that country do not draw them out of the quarry in winter, because they are subject to the frost. And it has been divers times seen, that upon thaws, the rocks, without being cut, have fallen down and killed many.'

* Of the imperfection of Physics. Maitre Bernard Palissy.

BUT it may yet seem far more unlikely, that frosts should get into metals themselves, and yet having asked the newly-mentioned Polonian, whether he had observed any thing of that kind; he answered, that he had often by drawing out his sword and pulling out his pistols, when he had been long in the field, and came into a hot room, found them quickly almost whitened over, by a kind of small hoar frost. But whether this were, as he conceived, any thing, that was drawn out of the steel, and settled on the surface of it, I want circumstances enough to make me willing to determine. But if we will credit *Olaus Magnus*, it must be confessed, that considerably thick pieces of iron and steel itself will, in the northern regions, be rendered so brittle by the extreme frost, that they are fain to temper their instruments after a peculiar manner: his words, which being remarkable I forbear to alter, are these; *Videntur præterea ferrei ligones certa ratione fabricati, quia his spissa atque indurata glacies cæteris instrumentis ferreis non cedens facilius infringitur, dum aliæ secures chalybe permixtæ, in vehementi frigore ad solum glaciei vel virentis arboris ictum instar vitri rumpuntur, ubi ligones prædicti sive ferreæ hastæ fortissimi manent.* Which testimony, notwithstanding what some have written to this author's disparagement, does not seem to me at all incredible. For I remember, that even here in *England* I have had the curiosity to cause trials to be made in very frosty weather, whereby, if an expert smith I then used to employ, did not *gratis* deceive me in the irons I imployed, that metal may by such degrees of cold, as even our climate is capable of, be rendered exceeding brittle, as he several times affirmed to me, that there are some kinds of iron, which he could hammer, and turn, as they phrase it, cold in open weather, which yet in very hard frosts would become so brittle, as by the same way of working easily to break, if not to fly asunder. And this he affirmed both of iron and steel; of which latter metal another very skilful workman, whom I also consulted, certified the like; but though this disagreed not with trials purposely made on iron rods, as they had informed me, yet presuming, that in such a nice piece of work as a spring, some further satisfaction about this matter might be obtained, I inquired of a very dexterous artificer, that was skilled in making springs for others, whether or no he found a necessity of giving springs another temper in very frosty weather, than at other seasons; and he answered me, that in such weather, if he gave his springs the same temper, that he did in mild and open air, they would be very apt to break. And therefore in very sharp seasons he used to take them down lower, as they speak, that is, give them a softer temper than at other times; which, as it makes it probable, that the cold may have a considerable operation upon bodies, upon which most men would not suspect it to have one; so that discovery may afford a hint, that may possibly reach further than we are yet aware of, touching the interest, that cold may have in many of the phenomena of nature.

I SHOULD here subjoin, that in prosecution of what is delivered in the XXth section about the weight of solid bodies, that I there wished might be exposed to a congealing air, I did cause some trials of that kind to be made in a very frosty night, especially with bricks; but something, that happened to the only scales I then had fit for such an experiment, made me doubt, whether some little increase of weight, that seemed to be gained by congelation, were to be relied upon, though there did not appear any hoar frost, or other thing outwardly adhering, to which the effect could be ascribed.

IT is a tradition, which the schools and others have received with great veneration from their master *Aristotle*, that hot water would sooner freeze than cold: but I do not much wonder, that the learned *Cabeus*, as I find him quoted by *Bartholinus*, should contradict this tradition, though he be himself a commentator upon that book of *Aristotle*, wherein it is delivered. For I could never satisfy myself, that there is (at least with our water, and in our climate) any truth in the assertion, though I have made trial of it more ways than one; but it may very well suffice to mention a few of the plainest and easiest trials, with whose success I am well satisfied as to the main, as the reader also will, I doubt not, be; though not having, for want of health, been able to have so immediate an inspection of these, as of the rest of my experiments, I was fain to trust the watchfulness of my servants (whom I was careful to send out often) to bring me word, how long after the first freezing of the cold water, it was before the other began to be congealed.

WE took then three pottingers, as near of a size as we could; and the one we filled almost to the top with cold water, the other with water, that had been boiled before, and was moderately cooled again, and the third with hot water: these three vessels were exposed together in the same place to the freezing air.

IN the entry of one of the trials, I find, that being all three put out at half an hour after eight of the clock, the pottinger, that contained the cold liquor, began to freeze at $\frac{1}{4}$ after ten.

THAT, which contained the water heated and cooled again, began to freeze $\frac{3}{4}$ past ten.

AND that, which contained the hot water, at half an hour after eleven, and somewhat better. So that though all froze within the compass of two hours, yet the cold water began this time to freeze an hour and $\frac{1}{4}$ sooner than the hot.

THESE pottingers were earthen, but I elsewhere made the trial of others of metal, and there also the cold water began to freeze, both before that, which had been heated and cooled again, and long before the hot.

ANOTHER time I measured out the water by spoonfuls into pottingers (not having then by me any fit scales to weigh it) to be the more sure, that the quantities of water should not be considerably unequal, and then also the cold water froze a considerable while before the hot.

BUT my usual jealousy in the making nice experiments tempting me to enquire, whether the water in some of the former trials had not been heated in a stone bottle, nor a skillet, it was confessed, that it was so, but that the bottle used to contain nothing but beer, and had been washed before hand: and though I did not think, that the bottle could have any considerable influence on the experiment; yet lest it should be suspected, that the scalding water might have imbibed some spirituous parts remaining yet among the minute dregs of beer in the pores of the bottle, for the greater security I caused the water to be heated in a skillet; and because in one of the

trials made in a village, where we had not choice of pottingers, the cold water chanced to be put into one, that afterwards seemed less than that wherein the hot was exposed, I did this very day repeat the experiment, by putting the cold water into a somewhat larger pottinger, heating the other water in a skillet, and the event of the trial is this;

THAT the cold water being put out with the rest, at $\frac{3}{4}$ after 6, began to freeze somewhat before $\frac{1}{2}$ after 7.

THE water heated and cooled again began to freeze $\frac{1}{4}$ after 7. And having these frozen waters a little while by me, I sent in, for my own further satisfaction, for the hot water, and found it not to be, in the least, frozen at half a quarter after eight. So that supposing it to continue half a quarter of an hour longer before the beginning of its congelation *, it was twice as long ere it began to freeze, as the cold water had been.

* As it afterwards did at the least.

By which we may see, how well bestowed their labour hath been, that have puzzled themselves and others, to give the reason of a phenomenon, which perhaps with half the pains they might have found to be but chimerical.

I HAVE been the more circumstantial in setting down these trials, that I may express a civility to so famous a philosopher as *Aristotle*; and also because artificial congelations, which we can commonly best command, and which we have the ofteneft used about our other experiments, are not so proper for this. For having formerly had the curiosity to take two pipes of glass made of the same cylinder, that they might be of equal bore, and having sealed each of them at one end, and having filled both to the same height, and then stirred them to and fro together in a mixture of beaten ice, water and salt, (which mixture I make use of for the effecting sudden congelations) I found both waters to freeze too quickly to make a notable disparity in the length of times, that they remained uncongealed: and we will not, on this occasion, omit one phenomenon afforded us by these trials, because it may admonish men, how cautious they ought to be in making nice experiments. For having once made the formerly mentioned trial, with glass pipes, that were but slender (as not exceeding the bigness of a man's fore-finger) and having for greater caution put the hot water first into one glass, and then into another, we found one time, that the hot water froze first, and wondering at it, we examined the glasses, and perceiving one of them to be more conical or acuminate, where it had been sealed up, than the other, it seemed probable, and afterwards appeared true, that the water in this accumulated part, being suddenly frozen by reason of the slenderness of the glass there, promoted and accelerated the congelation of the rest; so that whether it were the cold or the hot water, that was put into that pipe, it would thereby gain a manifest advantage.

IN the foregoing experiments (made in pottingers) I made use not only of cold and hot water, but of water that had been heated and cooled again, though not reduced to its full pristine coolness, to prevent the objections of some, that might pretend, that such water would have frozen sooner than cold, which yet would not solve the common opinion which specifies not such water.

P O S T S C R I P T.

AND it seems, that such cautions, as I have been mentioning, are not altogether useless. For accidentally casting my eye upon the *Circulus Pisanus* of *Berigardus* upon *Aristotle's* meteors, I somewhat wondered to find, that an author, who is looked upon to be a great adversary of *Aristotle*, except in his dangerous and ill-grounded conceit of the eternity of the world, and some other erroneous opinions, does yet endeavour

endeavour to justify *Aristotle* by affirming, that this experiment will succeed, if by heated water we understand that, which having been heated, is suffered to cool again, till it be reduced to the temper of other water, which was not heated. For this refrigerated water, he says, he has found to congeal much sooner than the other water: but this I confess I am very unapt to believe. For having divers times caused cold water to be exposed to the air in frosty weather, with that, which had been heated and cooled again, and having set sometimes one of my domesticks, sometimes another, to watch them, the events did very much disavour the assertion of our author, though care was had of the circumstances most considerable in such an experiment, as the matter, size and shape of the vessels; the equal degree of cold in the two several parcels of water (into both which I sometimes dipped my finger to judge of them before they were exposed) and the place, in which they were put both together to be frozen. But for further satisfaction, we elsewhere took two pottingers, bought purposely for the making of experiments, of the same size and shape, and in the same shop: one of these we almost filled with cold water out of a glass, wherein we marked, how high that water reached, that by filling the same glass to the same height with the refrigerated water, we might be able to measure out the same quantity into the other pottinger. This done, I appointed one, whose care I had no reason to distrust, to examine the tempers of these several waters, with a more than ordinarily sensible weather-glass, as a far safer criterion, than the bare touch, to judge of the coldness of liquors. These being reduced to the same temper, were exposed to a very sharp air, and there watched by the person, whom (being not well, and unable to support such weather my self) I appointed to attend the experiment, and he, according to direction, finding them begin to freeze, as it were at the very same time, brought me in the two pottingers, in each of which I saw the beginnings, and but the beginnings of congelation, where the upper surfaces of the waters were contiguous to the containing vessels. So that having made this experiment with much greater exactness than probably *Berigardus* did, or, for want of such instruments as I used, could make it, I cannot but suspect, supposing the common waters, he and I used, to be of the same nature, that he was either negligent or over-seen in affirming, that heated and refrigerated water will cool so much sooner *. And as I am not convinced by experience, that it will freeze sooner at all, so till he have better made out the reason he seems to give of the phenomenon, I must question, whether he rightly ascribe after *Cabæus* (if I much misremember not) the congelation of water to a certain coagulum, distinct from the cold spirits, that plentifully mingle with the water, which coagulum it seems (for his style is not wont to be very perspicuous) that he would have to consist of certain dry corpuscles, no less necessary to congeliate water, than runnet to curdle milk: and for what this author says †, that he must have employed boiling or scalding water, who affirms it to be less congelable than other, that mistake may be sufficiently disproved by the several above recited trials, wherein we found water, moderately refrigerated, to freeze much later than cold. And whereas *Berigardus* intimates, that the person, whosoever he be, that he dissents from, does unskillfully suppose warm salt-water to be the less disposed to congelation for being salt, our author is therein also mistaken; for though it be true, what he alledges, that salt outwardly applied promotes the congelation of water, yet that,

* *Quare ferventem aquam adhibuisse oportet qui asserit eam esse minus gelabilem, præcipue salisam,* pag. 571.

† *Tam cito illa congelabat, ut eximirem ex eo crustam unam aut alteram antequam non calefacta vel levissime concrevisset,* pag. 572.

dissolved in water, has a contrary effect, may appear by the familiar observation, that sea-water is more difficult to be congealed than fresh water. And to shew, that it is not a property of sea-water, but a water impregnated with common salt, I have several times tried, that a strong solution of such salt in ordinary water, will not at all be congealed by the being exposed to the air, even in very sharp frosts; as may be easily collected from some of the experiments mentioned in the former part of this book. Another particular there is (about the use of alum in reference to freezing) in this often-cited passage of *Berigardus*, which I might here examine, if my haste and my indisposedness to engage in a controversy of small moment, did not injoin me to defer it till a fitter occasion.

Here the
postscript
ends.

To confirm the power ascribed in the sixth section to cold, as to the long preservation of bodies from corruption, it will not be amiss to add these two remarkable passages, the latter of which affords a good instance of the improvement, that may be made of some degrees of cold to the uses of human life.

THE first observation is afforded us by some of our country-men, in a voyage extant in *Purchas*, where the writer of it speaks thus, of the Samojeds, whose country he visited: 'Their dead they bury on the side of the hills, where they live (which is commonly on some small islands) making a pile of stones over them, yet not so close, but that we might see the dead body, the air being so piercing, that it keepeth them from much stinking favour: so likewise I have seen their dogs buried in the same manner.'

Purchas,
lib. 4. cap.
19. pag.
844.

THE other observation is given us in the description of *Ireland* (made by one that visited it) to be met with in the same *Purchas's* collections, where among other things he gives us this account; which, if I mistake not, I have had confirmed by others, of their strange way of ordering and preserving their fish. 'Having taken them, they pluck out the bones, and lay up their bowels, and make fat or oil of them. They heap up their fish in the open air; and the purity of the air is such there, that they are hardened only with the wind and sun, without salt, better surely than if they were corned with salt. And if they kill any beast, they preserve the flesh without stink or putrefaction, without salt, hardened only with the wind.'

lib. 3.
cap. 22;

I KNOW not, whether it will be worth while to add to the fifth and sixth numbers of the seventh title, that, for further confirmation of our opinion, that it is not nature's abhorrency of a vacuum, but the distension of the water, that breaks glasses, when the contained liquors come to be congealed, I did on set purpose fill several phials (some at one time, and some at another) to the lower parts of their necks (most of which were purposely made long) with common water, and though they were all left unstopped, that the external air might come in freely to them; yet not only one of them, that I stirred up and down in a mixture of beaten ice, salt, and water, was hastily broken upon the congelation of the contained water, but several others, that were exposed to be frozen more leisurely by the cold air only, were likewise broken to pieces, by the expansion of the freezing water, as appeared both by the gaping cracks, and also by this, that the ice was considerably risen in the necks above the water's former stations, which had been noted by marks before; and if it had been more easy for the included water to make it self room, either by stretching the glass, or (rather) heaving the superficial ice congealed at first in the neck, or by both those ways together, than to break the vessel, the phial would probably have remained intire.

I SAY probably, because I am not sure, that there may not sometimes intervene, in these experiments, somewhat, that may need further observation and inquiring. For as it seems, that what I have been lately saying may be confirmed by an unstopped phial, which was exposed at the same time to congelation, with this success, that without breaking the phial the water was frozen, and the ice in the neck impelled up a good way above the height, at which the liquor rested before it began to congeal; so, on the other side, I remember, that I have sometimes a good store of liquor frozen in a phial, without breaking the glass, though a phial were stopped: as if the difference, that I have on other occasions observed betwixt glasses, whereof some are very brittle, and others more apt to yield, might have an influence on such experiments, or that some peculiar softness, or other property of the ice, that afforded me my observation, or else some other thing not yet taken notice of, were able to vary their success.

IN confirmation of what is delivered in the seventh section, about the expansion of water by freezing, I shall add, that having caused some strong glass-bottles of a not inconsiderable bigness to be filled with a congealable liquor, excepting the necks, which were filled with sallet-oil, I observed, that in a somewhat long, and very sharp frost, the contained water was so far expanded by congelation, that it not only thrust up the corks, but the cold having taken away the defluency of the oil, that liquor together with the water, that could no longer be contained in the cavities of the glasses, being, as it seemed, frozen as fast as it was thrust out of the neck, there appeared quite above the upper part of the bottles, cylinders of divers inches in height, consisting partly of concreted oil, and partly of congealed water, having on their tops the corks, that had been raised by them.

It is a tradition very current among us, that when ponds or rivers are frozen over, unless the ice be seasonably broken in several places, the fishes will die for want of air *. And I find this tradition to be more general, than, before I made particular enquiry into it, I knew of. For *Olaus Magnus* mentions it more than once, without at all questioning the truth of it, but rather, as if the general practice of the northern nations to break in divers places their frozen ponds and rivers, were grounded upon the certainty of it. In the twentieth book (which treats of fishes) after having spoken of the reasons, why the northern fishermen employ so much pains and industry to fish under the ice; and having said among other things, that the nature of the fish exacts it, he adds this reason, that, *+ Nisi glacie perforata respiracula susciperent, quotquot in flumine vel stagno versantur, subito morerentur.* Another passage of the same author, and taken likewise out of the same (20th) book, you may meet with in the margin, though in another place he seems to intimate another, and not an absurd, reason of the death of fishes in winter; where advertising the reader, that ponds and lakes did generally begin to freeze in † *October*, he adds, that fishes are usually found suffocated, when the thaw comes, where veins (or springs) of living water do not enter: by

* *Volentes igitur piscari sub glacie duo magna foramina, latitudine 8. vel. 10. pedum centum & quinquaginta vel 200. passibus à se invicem directa distantia, aperiunt, inter quæ 30 vel 40 minora foramina, latitudine unius pedis & semis, ab utroque latere distantia 30. pedum intermedia constituunt, tum per ea, &c. Olai Mag. lib. 20.*

+ *Olaus Mag. Titulo, De cursu glaciali, pro piscibus. Quæ (Anguille) si totaliter glacie constrictæ fuerint, simul omnes respiraculum ab aere non habentes pariter suffocate moriuntur.*

† *Præmittendum est quod generaliter omnes lacus & stagnales aquæ in mense Octobri incipiunt congelari, glaciæque aucto frigore in plerisque locis tantum condensari, ut ubi vena lacu & stagno viventis aquæ non intrant, pisces suffocati tempore resolutionis glaciæ inspiciantur; verum ne hæc suffocatio tam dispendiosa fiat, diligentia piscatorum continue glaciæ ipsa perfringitur, ne congeletur. Olai Magni, lib. 1. Titulo de transitu glaciali, &c.*

which

which passage he seems to make the want of shifted water co-operate to the suffocation of the fishes. And to the same purpose I shall now add, that having enquired of a learned native, that had lived about *Cracovia*, (whose territory is said to abound much in ponds) whether the Polanders also used the same custom; he answered me, that they did, and that sometimes in larger ponds they were careful to break the ice in eight or ten several places, to make so many, either vents or air-holes, for the preservation (as they supposed) of the fish. And when I inquired of the often-mentioned Russian emperor's physician, whether in *Muscovy* the frost killed the fish in the ponds, in case the ice were not broken to give them air: he answered, that in ordinary ponds it were not to be doubted, but that in great lakes he could not tell, because the fishermen used to break many great holes in the ice for the taking of the fish. For at each of these holes they thrust in a net, and all these nets are drawn up together in one great breach made in some convenient place near the middle of the rest.

It appears then, that the tradition is general enough; but whether it be well grounded enough, I dare not determine, either affirmatively or negatively, till trial have been made in ponds with more of design or of curiosity, and watchfulness, than I have known hitherto done; men seeming to have acquiesced in the tradition without examining it, and to have been more careful, not to omit what is generally believed necessary to the preservation of fish, than to try, whether they would escape without. Wherefore, though, for aught I know, the tradition may prove true, yet to induce men not to think it certain, till experience has duly convinced them of it, I shall represent, that as much as I have in other treatises manifested how necessary air is to animals; yet whether fishes may not live, either without air, or without any more of it, than they may find interspersed in the water they swim in, has not yet, that I know of, been sufficiently proved. For what we have attempted of that nature, in our pneumatical engine, whether it be satisfactory or not, is not yet divulged. And I remember not to have hitherto met with any writer, (except *Olaus* be construed to intimate so much) that affirms upon his own observation, that the want of breaking ice in ponds has destroyed all the fish. Besides, that possibly in frozen ponds, there may be other reasons of the death of fishes, that there are killed (if any store of them be so) by very sharp frost. For who knows what the locking up of some kinds of subterranean steams, that are wont freely to ascend through water unfrozen, may do to vitiate and infect the unventilated water, and make it noxious to the fishes, that live in it? perhaps also the excrementitious steams, that insensibly issue out of the bodies of fishes themselves, may, by being penned up by the ice, contribute, in some cases, to the vitiating of the water, at least in reference to some sort of fishes. For being desirous to learn from a person curious of the ways of preserving and transporting fish, whether some fishes would not quickly languish, grow sick, and sometimes die outright, if the water they swam in were not often shifted, he assured me, that some kinds of them would: and it has not yet, that I hear of, been tried, whether or no, though ponds seldom freeze to the bottom, yet the water, that remains under the ice (in which itself some fishes may be now and then intercepted) may not, even whilst it continues uncongealed, admit a degree of cold, that though not great enough to turn water into ice, may yet be great enough, when it continues very long, to destroy fishes, though not immediately, yet within a less space of time, than that, during which the surface of the pond continues frozen. But it is not worth while to be solicitous about conjectures of causes, till we are sure of the truth of the phenomenon; and these things are proposed not so much to confute the tradition, we have been speaking of, as to bring it to a trial, which, having no opportunities to make in ponds,

ponds, I endeavoured, as well this winter as formerly, to obtain what information I could from trials made in small vessels, with the few fishes I was able to procure. And I shall subjoin most of these trials, not because I think them very considerable, but because they are, for aught I know, the only attempts of the kind, that have yet been made.

To satisfy myself, whether the ice's denying access to the air was that, which destroyed fishes in frozen ponds, I thought upon this expedient; I procured a glass vessel with a large belly, and a long neck, but so slender, that it was only wide enough for the body of the fishes to pass through: and then having filled the vessel with some live gudgeons, and a good quantity of water, the neck of it was made to pass through a hole, that was left, or made for it in the midst of a metalline plate, or wooden trencher, which could descend no lower than the neck, because of the inferior part of the glass, that would not suffer it, and which served to support a mixture of ice (or snow) and salt, which was applied round about the extant neck of the glass. By this contrivance I proposed to myself a double advantage: the first, that, whereas in broad vessels it is not always so easy, as one would think, to be sure, that the surface of the water is quite frozen over in every part; by this way I could easily satisfy myself, by inverting the glass, and observing, that the ice had so exactly choaked up and stopt the neck, that no drop of water could get out, nor any bubble of air get in, and yet the fishes had liberty enough to play in the subjacent water. The other conveniency was, that the frigorifick mixture being applied to the neck, no water was congealed, or extremely refrigerated, but that, which was contained in the neck; so that there seemed no cause to suspect, that in case the fishes, thus debarred of air, should not be able to live in the water, it was rather cold, than want of air, that killed them. But though not having then been able, by reason of a remove, to prosecute these trials to the utmost, nor to register all the circumstances, I shall not lay much weight upon it; yet I remember, that the included fishes continued long enough alive, to make me shrewdly suspect the truth of the vulgar tradition.

ANOTHER time being destitute of the conveniency of such glasses, I caused some of the same kind of fishes to be put into a broad and flat earthen vessel, with not much more water, than sufficed perfectly to cover them; and having exposed them all night to a very intense degree of cold, I found the next morning, that some hours after day, they were alive, and seemed not to have been much prejudiced by the cold, or exclusion of air. It is true, that there was a very large moveable bubble under the ice; but that seemed to have been generated by the air, or some analogous substance, emitted out of the gills or bodies of the fishes themselves: for, that the surface of the water was exactly frozen over (which does not in such trials happen so often, as one would think) I found, by being able to hold the vessel quite inverted, without losing one drop of water. And that this large bubble might possibly proceed from the fishes themselves, I was induced to suspect, because having at different seasons of the year, for divers purposes, kept several sorts of fishes, and particularly gudgeons, for many days in glass vessels, to satisfy myself about some phenomena I had a mind to observe, I have often, by watching them, seen them lift up their mouths above the surface of the water, and seem to gape and take in air, and afterwards let go under water out of their mouths and gills divers bubbles, which seemed to be portions of the air they had taken in, perhaps a little altered in their bodies. And particularly in lampreys (of which odd sort of fishes I elsewhere make mention) I have, with pleasure, both observed and shewed to ingenious men, that being taken out of the water into the air, and then held under water again, they very manifestly appeared to squeeze

squeeze out, and that not without some force, at those several little holes, which are commonly mistaken for their eyes, numerous and conspicuous bubbles of air, which they seemed to have taken in at their mouths, if not also at those holes. But of these matters, a fitter occasion may perhaps invite me to say more. To return now to our gudgeons, I shall add, that to satisfy myself further, what cold and want of air they may be brought to support, I exposed a couple of them in a basin, to an exceeding bitter night; and though the next day I found the ice frozen in the vessel to a great thickness, and one of the fishes frozen up in it, there remaining a little water unfrozen, the other fish appeared through the ice to move to and fro; and the ice being afterwards partly thawed, and partly broken, not only that fish was found lively enough, but the other, which I alone judged not to be quite dead, though, when the ice was broke, it lay moveless, did, in a few minutes, so far recover, as to tow after it (if I may so speak) a good piece, into which his tail remained yet inserted. And though one of these, and some other gudgeons, that had been already weakened by long keeping, were once more exposed in the basin to the frost and suffered to lie there, till they were frozen up; yet the ice being broken, in which they were inclosed, though their bodies were stiff and crooked, and seemed to be stark dead, lying in the water with their bellies upwards, yet one of them quickly recovered, and the other not very long after began to shew manifest signs of life, though he could not in many hours after so far recover, as to swim with his back upwards. It is true, that these fishes did not long survive; but of that, two or three, not improbable reasons, might be given, if it were worth while to name here any other than this, that the ice, they had been frozen up in, or the violence, that was offered them by the fragments of it, when it was broken, had wounded them, as was manifest enough by some hurts, that appeared upon their bodies; yet some other gudgeons were irrecoverably frozen to death, by being kept inclosed in ice, during (if I misremember not the time) three days. And as for other animals, I caused a couple of frogs to be artificially frozen in a wide-mouthed glass, furnished with a convenient quantity of water: but though they seemed at first inclosed in ice, yet looking nearer, I found, that about each of them there remained a little turbid liquor unfrozen, as if it had been kept so by some expirations from their bodies. Wherefore causing either the same, or two others, (for I do not punctually remember that circumstance) to be carefully frozen, and for a considerable while, I found, that notwithstanding the ice, into which most part of the water was reduced, not only one of them before the ice was broken appeared to be perfectly alive, but the other, that was moveless and stiff, and lying with the belly upwards in a basin of cold water, whereinto it was cast, did in a very few minutes begin to swim about in it. I should have made more trials at least, if not also more satisfactory ones, if I could have had fishes, and vessels, and cold weather at command: but upon the whole matter, though the tradition, we have been examining, may perhaps have something of truth in it, yet it seems to deserve to be further inquired into, both in reference to the truth of the matter of fact, *the death of fishes in frozen ponds and rivers*, and in reference to the cause, whereto that effect is imputed.

I MET with an odd passage in Captain *James's* voyage, which, if it had been circumstantially enough set down, might prove of moment in reference to the weight of bodies frozen and unfrozen; and therefore, though I would not build any thing on it, yet I shall not omit it. 'The ninth (says he, pag. 82.) we hoisted our beer and cyder, and made a raft of it, fastning it to our shoar-anchor. The beer and cyder sunk presently to the ground; which was nothing strange to us, for that any wood

or

“ or pipe-staves, that had lain under the ice all winter, would also sink down so soon
 “ as ever it was heaved over board.”

ABOUT the duration of ice I forgot, through haste, to add a relation of Captain James's, whereby it may appear, that though wine abounds with very spirituous and nimble parts, whence it resists congelation far more than water, yet if even this liquor came once to be congealed, the ice made of it may be very durable. For he sets down in his journal, that when he came to his ship again, he found a butt of wine, that had been all the winter in the upper deck, ‘ to continue as yet all firm frozen, though it were then the month of May.’ (pag. 47.)

WHEN I treated of the great proportion in some pieces of ice, that were aground, instead of taking notice of a great piece of ice mentioned by *Gerat de Veer*, to be 52 fathom deep, the passage, that was to be transcribed, was this other, hard by, which contains two examples of towers of ice, where the extant part reached upwards. ‘ We saw (says he) another great piece of ice not far from us, lying fast in the sea, that was as sharp above, as if it had been a tower; whereunto we rowed, and casting out our lead, we found that it lay 20 fathom fast on the ground under the water, and 12 fathom above the water.—We rowed to another piece of ice, and cast out our lead, and found that it lay 18 fathom deep, fast on the ground under the water, and 10 fathom above the water.’

Purchas,
 lib. 3.
 cap. 5.
 pag. 487.

THAT snow lying long, and too long on the ground, does much conduce to the fertilizing of it, is a common observation of our husbandmen. And *Bartholinus* in his treatise of the *use of Snow*, brings several passages out of authors to make it good: to which I shall add the testimony of our learned English ambassador, Dr. *Fletcher*, who speaking of the fruitfulness of the soil, and hasty growth of many things in the great empire of *Russia*, gives this account of it.

‘ THIS fresh and speedy growth of the spring there seemeth to proceed from the benefit of the snow, which all the winter time being spread over the whole country, as a white robe, and keeping it warm from the rigour of the frost, in the spring-time (when the sun waxeth warm, and dissolveth it into water) doth so thoroughly drench and soak the ground, that it is somewhat of a slight and sandy mold, and then shineth so hotly upon it again, that it draweth the herbs and plants forth in great plenty and variety, in a very short time.’

Purchas,
 lib. 3.
 cap. 1.
 pag. 415.

As we made some trials to discover, whether congelation would destroy or considerably alter the odours of bodies: so we had the like curiosity in reference to divers other qualities, not only those, that are reputed manifest, as colours and tastes, the latter of which we sometimes found to be notably changed for the worse in flesh congealed, but also those, that are wont to be called occult: and among the qualities of this sort, I had particularly a mind to try, whether the purging faculty of catharticks would be advanced or impaired, or destroyed by congelation; and for this purpose I caused to be exposed thereunto divers purging liquors, some of a more benign, and some of a brisker nature, and that in differing forms, as of syrup, decoction, infusion, &c. But for want of opportunity, to try upon the bodies of animals, what change the cold had made in the purging liquors, it had congealed, I was unable to give my self an account of the success of such experiments. Only since, in some of these trials I had a care to make use of cathartick liquors prepared by fermentation (which way of preparing them is it self a thing I elsewhere take notice of, as not unworthy to be prosecuted) I shall add on this occasion, that fermentation is so noble and important a subject, that the influence of cold upon it may deserve a particular inquiry. And I am invited to think, that that influence may be very considerable,

partly

partly by my having observed (upon a trial purposely made) both that raisins and water, (with which I was used to make artificial wines) did not in many days, whilst the weather was very frosty, so much as manifestly begin to ferment, though the water were kept fluid: and partly by my having observed, that beer will continue as it were new, and be kept from being, as they call it, ready to drink, much longer than one would readily suspect, if very frosty weather supervene, before it have quite finished its fermentation; infomuch, that an experienced person, of whom I afterwards inquired about this matter, assured me, that beer not duly ripe, would not sometimes in five or six weeks of very frosty weather, be brought to be as ripe as in one week of warm and friendly weather. But we have a nobler instance to our present purpose, if that be true, which I learned from an intelligent Frenchman, whom I consulted about this matter. For, according to this experienced person, the way to keep wine in the must (in which state, its sweetness makes it desired by many) is to take newly expressed juice of grapes, and having tunned it up before it begins to work, to let down the vessels (which ought to be very carefully closed) to the bottom of some deep well or river, for six or eight weeks, during which time the liquor will be so settled (if I may so speak) in the constitution, it has so long obtained, that afterwards it may be kept in almost the same state, and for divers months continue a sweet, and not yet fermented liquor; which some, in imitation of the French and Latins, call in one word, *Must*. And how, by the help of cold well applied, some other juices, that are wont to work early, and to be thereby soon spoiled, may be long kept from working, the reader may perchance learn in another treatise, to which such matters more properly belong.

It is known, that the schools define cold by the property they ascribe to it, of congregating both heterogeneous and homogeneous things. I thought it not amiss to attempt the making some separations in bodies by the force of cold. For if that hold true in this climate, which has been observed by travellers and navigators in northern regions, that men may obtain from beer and wine a very strong spirit, and a phlegm by congelation; it seems probable, that in divers other liquors the waterish part will begin to freeze before the more spirituous and saline: and if so, we may be assisted to make divers separations, as well by cold, as by heat, and dephlegm, if I may so speak, some liquors, as well by congelation as by distillation. But I doubt, whether the ordinary frosts of this country can produce a degree of cold great enough to make such divisions and separations in bodies, as have been observed in the more northern climates. For though having purposely hung out a glass-bottle with a quart of beer in it, in an extraordinarily sharp night, I found the next morning, that much the greatest part of the beer being turned into ice, there remained somewhat nearer the middle, but nearer the bottom, an uncongealed liquor, which to me and others seemed stronger than the beer, and was at least manifestly stronger than the thawed ice, which made but a spiritless, and, as it were, but a dead drink; yet in some other trials, my success was not so considerable as some would have expected. For having put one part of high rectified spirit of wine to about five or six parts, if I misremember not, of common water, and having put them into a round glass, and placed that in beaten ice and salt, though the mixture were in great part turned into ice; yet I could not perceive, that even two liquors so slightly mingled were any thing accurately severed from one another, although once, to enable my self the better to judge of it, the spirit of wine I employed was beforehand deeply tinged with cochineal; and therefore I the less wonder, that in claret wine I could not make any exact separation of the red and the colourless parts: I thought it not amiss to try, how far in some other liquors this way of separating the waterish, and more easily congealable

congealable part from the rest, would or would not succeed. And I remember, that a large glass vessel, wherein spirit of vinegar was exposed to the cold, a considerable part was turned into ice, whose swimming argued it to be lighter than the rest of the liquor. But though I put some of this ice in a glass by it self, to examine by its weight and taste, when thawed, how much it differed from the uncongealed part of the spirit, my hopes were disappointed by a misfortune, which was not repaired by my exposing afterwards a smaller quantity of spirit of vinegar to the nocturnal air; for that proved so cold, that the whole was turned into ice: wherefore I must reserve for another opportunity the prosecuting that experiment, as also the trying, whether a separation of the serous or the oleaginous parts of milk may be effected. For though once the frost seemed to have promoted a separation of cream, notwithstanding that the heat also may do it; and though another time there seemed to be another kind of divulsion of parts made by congelation; yet for want of leisure to prosecute such trials, they proved not satisfactory, no more than did some attempts of the like nature, that I made upon blood by freezing it. But notwithstanding these discouragements, I resolved to try, what I could do upon brine. For calling to mind the relations mentioned in the XVth title, and elsewhere, which seem to argue, that in some cases the ice of the sea-water may, being thawed, yield fresh water; and being the more inclined to think it worth trial, by a physician, I since happened to discourse with about this matter, who affirmed to me, that sailing along the coast of *Germany*, he had taken out of the sea ice, that being thawed, he found to afford good fresh water; I began to consider, whether we might not, by cold, free salt-water at some seasons of the year from a great deal of the phlegm, which it is wont to cost much to free it from by fire, and other means. For a little help towards the diminution of the fresh water is looked upon as so useful an experiment, by many, that boil salt out of the salt springs, that in some countries, that are thought the skilfullest in that trade, they make their salt-water fall upon great bundles of small brush-wood, that being thereby divided, and reduced to a far greater superficies, there may, in falling through, some of the purely aqueous parts exhale away: wherefore, dissolving one part of common salt in forty-four times its weight of common water, that it might be reduced, either exactly, or near, to the degree of saltiness, that has been by several writers observed in the water of our neighbouring seas, and having likewise caused another and much stronger brine to be made, by putting into the water a far greater proportion of salt, (for so there is in many of our salt springs) we exposed these several solutions to the congealing cold of the air in frosty weather, where the last mentioned solution being too strongly impregnated with the salt, continued some days and nights altogether uncongealed, but that weaker solution, which emulated sea-water, being exposed in a shallow and wide-mouthed vessel, (that shape being judged the most proper we could procure for our design) the large superficies, that was exposed to the air, did, as we expected, afford us a cake of ice; which being taken off, and the rest of the liquor exposed again to the air in the same vessel, we obtained a second cake of ice: and taking the remaining, which seemed to be indisposed enough to congelation, we found, that by comparing it with that, which was afforded us by the first cake of ice permitted to thaw, there appeared a very manifest difference betwixt the water, whereinto the ice was resolved, scarce tasting so much as brackish; whereas the liquor, that had continued uncongealed, was considerably salt in taste. And if I had had the conveniency of examining myself these two liquors hydrostatically, as I was fain to have them examined by another, I doubt not but by their weight I should have discovered precisely enough the difference between them (which the person I employed found to be considerable) and consequently should have been assisted

assisted to make an estimate of the advantage, that might be afforded by the operation of the cold towards freezing of the brine from its superfluous water. But though I had not a quantity of ice great enough to satisfy me, whether that little brackishness of taste, I have mentioned, proceeded from some saline corpuscles, that concurred to the constituting of the ice itself, or did only adhere to the lower part of it, among other particles of the liquor, that remained uncongealed; yet perhaps it were not amiss to try, whether in very large, though not deep vessels, this experiment, especially promoted by some expedients, that practice may suggest, may not, in some seasons and places, be brought to be of some advantage.

WHILST I was endeavouring by some of the above-recited experiments, to make some separations in liquors by congelation, I thought fit to try, by the same means, what separations I could make in some bodies, betwixt liquors, and those more stable parts, among which they were engaged; hoping, upon considerations, which it were too long to enumerate, that, if such attempts should succeed, they might afford hints of a luciferous nature. I took then divers vegetable substances of differing kinds, as turneps, carrots, beets, apples, and tender wood, freshly cut off from growing trees; as also divers animal substances, as muscular flesh, livers, brains, eyes, tongues, and other parts, and exposed them to a very sharp cold, that they might be thoroughly frozen. Now one of the chief things, that I proposed to myself in this attempt, was, to try, how far I could by congelation make discovery of any thing about the texture of animals and plants, that had not been taken notice of by anatomists themselves, and would scarce otherwise be rendered visible. And I easily found, that I had not groundlessly imagined, that in divers succulent bodies, both vegetable and animal, the sap or the juice, that was so dispersed among the other parts, and divided into such minute portions, as not to be manifestly enough discriminated, might, by congelation, be both discerned and separated from the rest. For in divers plants, I found the alimantal juice to be congealed into vast multitudes of distinct corpuscles of ice; some of which, when the bodies were transversely cut with a sharp knife, and left a while in the air, might be wiped or scraped off from the superficies of the body, upon which it would after a while appear in the form of an efflorescence, almost like meal: but in others I took a better and quicker course, for by warily compressing the frozen bodies, I could presently make the icy corpuscles start in vast numbers out of their little holes; and though some of these were so minute as to invite me to use a microscope, that magnified a little, (not having then any of my best at hand) yet in some bodies, and especially in carrots and beets, the icy corpuscles were big enough to be distinctly or apart conspicuous, insomuch that I was not mistaken in hoping, that the figures, as well as sizes, (for as to the colour, it was scarce discernible in the ice, produced in so deeply crimson a root, as the beet itself) of these little pieces of ice, might be guessed at by the bigness and shape of the pores, that were left in the more stable part, or (if I may so call it) the parenchyma of the root; though in making an estimate of these cavities, as well as in discovering the order, wherein they are ranged, I found it useful to cut the frozen roots, sometimes according to their length, and sometimes quite cross. For by that means there would appear in carrots, for example, of the larger sort, a great disparity in the order of the pores; which, when the root was divided by a plain parallel to the basis, appeared placed in lines almost strait, tending, almost like spokes of a wheel, from the middle to the circumference. But if the carrot were slit from one end towards the other, the icy corpuscles and pores would seemed ranged in an order, that would appear very differing, but which I have not now the leisure to describe; no more than what I observed with a microscope,

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about the ice and pores of apples, the tongues of animals, chips of green and sappy wood, &c. exposed to congelation. Only this I shall not pretermitt, that as I many years since made (and, as I now find, too freely communicated) an experiment (mentioned long after in other papers) of freezing the eyes of oxen, and other animals, whereby the soft and the fluid humours of that admirable organ may be so hardened, as to become tractable, even to unskilful dissectors; so I did, on this occasion, apply that experiment to the brains of animals, which, though too soft to be easily dissected, especially by those who are not dexterous, may, by congelation, be made very manageable by them: and besides, that in dissecting the hardened brain, it sometimes seemed, that the knife did cut through multitudes of icy corpuscles (as when one cuts a frozen apple) the substance of the brain seemed also to the eye to be stuffed with them, and the ventricles of it did at least conspicuously harbour pieces of ice, if it were not filled up with them. And the manifest difference of texture, that there is between the white and yolk of a thoroughly frozen egg, and also betwixt the crystalline and the aqueous, and the vitreous humours of the eye, wherein by congelation the crystalline alone loses its transparency, but acquires no conspicuous ice, whilst the others are full of ice, and that diaphanous; these and such like disparities, I say, may invite one to hope, that some things may, by congealing of bodies, be discovered about their texture, that may afford sagacious anatomists improvable hints.

I know not, whether it will be thought worth while to take notice, that neither an eye, nor a liver, nor a lean piece of flesh, nor a live fish, nor a living frog, being frozen and put into cold water, was observed to be upon its thawing cased with ice, as frozen eggs and apples are wont to be; because having forgot to make the experiment above once, I dare not much rely on it. But whereas we have formerly observed, that congelation does most commonly spoil, or at least impair eggs, and apples, and flesh, and many other bodies, I think it may not be unworthy to be considered, how far, and in what cases we may give a mechanical account of this phenomenon. For though the immersion of frozen bodies in cold water be allowed to thaw them, with less prejudice, than if they were thawed hastily by the fire, or suffered to thaw themselves in the air; yet there have been complaints made, that notwithstanding this expedient several bodies have been much the worse for having been thoroughly frozen, now since I have lately shewn, that in many stable bodies, the alimental juice is by congelation turned into ice, and have formerly evinced, that water and aqueous liquors are expanded by congelation, I see not, why we may not suspect, that the innumerable icy corpuscles, into which the alimental juice is turned by the frost, being each of them expanded proportionably to their respective bignesses, may not only prejudice the whole, by having their own constitution impaired, as has been formerly observed in Alicant, and other vinous liquors, but may, upon their expansion, crush in some places, and distend in others, the more stable parts, in whose cavities they were harboured; and thereby so vitiate their texture, as to impair some of their qualities, and dispose the compositum to corruption. How much confusion may prejudice tender bodies, and accelerate putrefaction, is evident in many fruits, especially the more tender ones, which having been bruised, quickly begin to rot in those parts, that have been injured. And it is agreeable to what has been formerly shewn, to conceive, that in congelation there seems to happen an almost innumerable multitude of little confusions, made by the fluid parts hardened and expanded by frost, of the formerly more stable parts every where intercepted between them: and though these icy corpuscles be but small, yet the sides of that stable
matter,

matter, that separates them, and which they endeavour to stretch or crush, are oftentimes proportionably thin.

AND we have formerly noted, that, besides that eggs will be burst by having their alimental juice frozen, both shingles and stones themselves may have their texture spoiled by the congelation of the mineral sap, that is in exceeding minute and insensible particles dispersed through those bodies: and the violation of the texture of plants, herbs, and animals, by the expansion of the aqueous and juicy particles, which, though they be not congregated, do abound in them, will be the less wondered at, if it be remembered, that our former trials manifest, that a few ounces of water congealed did not only burst glass and pewter vessels, but even the iron barrel of a gun.

WHILST I was upon these trials, I had also a curiosity to know, whether by freezing animals to death, I could discover any such change in the qualities or structure of their parts, as might help us to discover, by what means it is, that excessive colds kill men in northern countries, since such a discovery might probably be of good use to the people that live in those gelid regions: but having taken a young rabbit, as the tenderest and fittest beast, I could then procure for such a trial, and having exposed him all night to an extraordinarily bitter frost, without finding him otherwise mischieved by it, than that one of his legs was swelled and grown stiff, I was more inclined to resign over to others, than to repeat myself what seemed to be an ill-natured experiment, though perhaps it may have much less of cruelty than one would think, since some of our former observations have made it probable, that oftentimes the extinction of life by cold is a more indolent kind of death than almost any other. But in a rabbit purposely strangled, and presently exposed intire to a bitter cold, we found ice produced in such parts, as would have made us prosecute the trial, had the want of such animals and of leisure not hindered us.

IT is affirmed by divers eminent writers, and those modern ones too, that water impregnated with the saline parts of the plants, and afterwards frozen, will exhibit in the ice, the shape of the same plant; and the learned, but I fear too credulous, *Gaffarel* tells us, that this is no rarity, being daily shewn by one *Monsieur de la Clave*. But to what we have already published in another treatise *, to shew that this experiment, as it is wont to be delivered, is either untrue, or very contingent; we shall need but to add, that, since the experiments there mentioned, we did again lately try, what could be done with decoctions, that were richly imbued, and highly tinged with the spirituous parts of the vegetables; but this ice was by no means so figured as the patrons of the tradition promise: and I remember, that having also made, for curiosity sake, a lixivium with sixteen parts of water, and but one of salt of potashes, that the mixture might be sure to freeze; and having exposed the liquor in a thin glass phial to an exceeding cold air, we found the copious ice produced to lie on the top in little sticks, not unlike those prismatical bodies, wherein salt-petre is wont to roch; and those parts of this ice, that were beneath the water, were shot in thin parallel plates, exceeding numerous, but (as one of our notes expressly informs us) no way in the shape of trees, by whose incineration nevertheless Polonian pot-ashes (as eye-witnesses, that deal in them, inform me) are made.

LONG after the making of the newly recited experiment, I chanced to find, that the learned *Bartholinus* in the treatise, we have often had occasion to take notice of, says, * That the water, wherein cabbage has been decocted, will, when frozen,

* Rem vero adeo obscuram exemplis similibus illustrabo brassicæ: aqua congelata brassicam representat, spiritibus vegetalibus à frigore concentratis. Tho. Bartholinus de usu nivis, pag. 17.

‘ represent a cabbage; the vegetable spirits being, as he supposes, concentrated by the cold.’ How well this experiment may succeed, when made in a cold country like his, I do not know; but not having my self, when I first took notice of it, the opportunity to try it satisfactorily by help of a frosty night, all I could do, was, to take a good decoction of cabbage, and filtrate it through cap paper, that it might be, though yellow, yet clear; and then by the circumposition of our frigorifick mixture, we froze this liquor in a thin glass phial, but the ice did not, either to me or others, appear to have any thing in it like a cabbage, or remarkably differing from other ice. And being afterwards befriended with two or three frosty nights, we exposed a decoction of cabbage, to be congealed by the nocturnal air alone, without the help of art; but neither this way did the experiment succeed well. And tho’ once a few ounces of the decoction being lightly frozen in a phial, there appeared in the thin ice, that adhered to the inside of the glass, a figure not so very unlike that of a cabbage-leaf, but that some such accident may have invited our learned author to think, that the representations of cabbages would constantly appear in their frozen decoctions; yet I was inclined to think this figuration rather casual, by the curiosity I have had to freeze the decoctions of several herbs, some of them spirituous enough, as rosemary, and penny-royal, without being able to find in the ice, I obtained from them, any conviction of the truth of the tradition we are examining. And I have lately had more than once, by freezing fair water alone, after a certain manner, ice, that seemed much more to exhibit the shapes of vegetables, than any decoctions of them, that I have made. And particularly I found more than once, that by putting hot water into a somewhat slender cylinder of glass, and agitating it in a frigorifick mixture, consisting of beaten ice, salt, and water, so that it was very speedily frozen thereby, it was congealed into an ice much more regularly and prettily figured, than I have seen it in divers of the waters impregnated with the fixed salts of plants, though of these we are told such wonders.

SUCH particulars as these, joined with what I have elsewhere observed to the same purpose, make me, I confess, somewhat surprized to meet in *Berigardus*’s forecited discourse upon *Aristotle*’s meteors such a passage as this; *Paucis notum est, cur intra glaciem cernuntur interdum multiformes stirpium imagines in ampullis vitreis, aquæ superficie tenus congelatæ plenæ. Hoc autem fit injecto in phialas sale diversarum stirpium, nam ubi erit sal alicujus plantæ & artemisæ, in suo lixivio glacies adherens vitro refert ejus folia laciniosa: similiter in alia phiala videbuntur folia plantæ, cujus sal in suam aquam fuerit injectus. Et nè quis hoc fortuito cadere putet, in aquâ sæpius solutâ & congelatâ eadem imagines semper occurrent, ut vel ex eo dixeris multiplicem spiritum salis in principiis naturalibus esse ponendum.* Thus far this author, who would have done well, if he had been so much more lucky than other men, as to have performed these things, to assure expressly of his having done so those many ingenious men, that much distrust the relations of those chymists, that are not of the best sort: and it is of such suspicious authors, that I here declare once for all, that I would have the reader understand all the passages of this book, wherein I may seem to say any thing (for avoiding of tediousness) indefinitely to the disparagement of chymists. And in case he had not tried them, he should, in gratitude to the authors of them, have told us, he had, what he delivers of them, but from others, and not have authorized the untried reports of writers, not always too veracious, by his building theories upon them. And as for what he immediately subjoins, and seems to rely on, out of *Quercetan*, (and other spagyric writers, who possibly had it themselves from him) about the seminal virtues surviving in the ashes of burnt plants; though I will not here examine, or absolutely reject the opinion, because the discussion of it belongs to another

another place; yet as to the experiment, whereon *Berigardus* and others rely, namely, that the lixiviums made of the ashes of plants, will exhibit, being congealed, the figures of the pristine vegetables; besides that a general conclusion, as to other plants, seems to be inferred from what happened in nettles only, I much doubt, whether that famous experiment it self of the frozen lixivium of nettles were more than casual, if it were not also assisted by an indulgent fancy. For having, after divers experiments made with other fixed salts, purposely repaired, for greater security, to the notedest chymist in *England*, to obtain from him some fixed salts, very faithfully prepared, and intimating withal, that it was to try such an experiment (which he was a favourer of) I did, by mingling these salts each in a distinct phial, sometimes with one, and sometimes with another proportion of water, and afterwards exposing them to the cold air, obtain indeed divers portions of ice, but without any such figurations, as the learned *Berigardus* would have expected; though some of these trials were made more than once, as well with the lixivium of nettles, as with the lees of other plants. So that I doubt this author is more scrupulous in admitting some important truths, in which the best philosophers, as well heathen as Christian, agree, than in examining the uncertain traditions of the chymists, whose unsatisfactory way of setting down matters of fact I am induced to take notice of his imitating, by finding, that in the very same page (that I have newly cited) he relates another chymical experiment in these terms: *Velim porro ostendere mirabili experientia quam sint penetrabiles aliqui spiritus corporei: exarentur in charta litera, aceto albo, quarum nullum vestigium deprehendatur, claudaturque primis foliis crassissimi alicujus libri. Paretur alia charta, quæ inficiatur aqua illa fetida, ubi dilutum fuerit auripigmentum, & exsiccata claudatur posiremis foliis ejusdem libri leviter compressi, statim videbis in priori charta literas conspicuas, perinde ac si atramento ductæ fuissent.* Now, though something like what is here proposed to be done, may be performed, and other phenomena of the experiment, such as he seems not to have been acquainted with, may be also exhibited, after the manner I have * elsewhere particularly set down; yet he must have good luck, that performs it only by the directions here given by our author, who by omitting one of the chief ingredients, and some requisite circumstances, appears indeed manifestly enough to have heard of such an experiment, but without seeming to have sufficiently known, what he pretends to teach, (at least as far as his bringing this experiment as a proof, and the obscure style, he is wont to employ in the little I have yet read of his book, permits me to judge:)

* In the unpublished section of the Usefulness of experimental philosophy.

BUT to return to the figurations of ice, notwithstanding such unsuccessful trials about them, as I have been mentioning, I will not deny it to be possible, that a prepossessed and favourable spectator may think himself to have discerned in the ice, the figures he looked for there. For since the writing of the essay not long since quoted, we have found, that several bodies, and even sea-salt, and alum, to whom nature has given their own determinate figures, have, when dissolved in water, concurred with it to exhibit an ice very oddly, as well as prettily, figured, (nor will I presume to determine the utmost, that a lucky observer may sometimes meet with in this kind) but to name at present no other arguments, the figures this way produced were too various and extravagant, not to be referred to chance, and not to afford instances, how much that can perform in the exhibiting of such apparitions.

Of the Usefulness of experiments.

ON which occasion I shall add, that I remember, I once shewed at the Royal Society a glass head, whose inside was lined with a certain substance, that passed for saline, fashioned into the figures of trees, as curious, as if they had been drawn by a limner:

limner: and yet as I produced these figures, only by rectifying common oil of turpentine, from sea-salt (which salt I elsewhere shew not to be necessary) in a certain degree of heat; so by varying that degree of heat, I could make the ascending steams settle in other figures. And I can easily produce very pretty shapes of trees by distillation of that, which belongs not to the vegetable, but the animal kingdom. And to these I could add divers other instances of the like tendency, to make it still the more probable, that though oftentimes one may happen to find pretty ideas, or apparitions in ice; yet the like, or as fine, may be produced by chance. And I have sometimes obtained by freezing infusions, decoctions, spirits, solutions, and other liquors, as vinegar (and particularly) milk, and even common water, figures, that were so pretty, but withal so unconstantly produced, and so easily variable by circumstances, that as it would fill a book particularly to describe them (which for that reason I hope to be excused for declining) so they would much delude him, that should suspect to find them every time the same, that he had found them once.

AND to intimate that by the by, to make several trials in a short time, and thereby produce variety of figures, it is not an ill expedient to expose the liquor one would have congealed, in very shallow vessels; or, if it be put into other vessels, to leave it but of very little depth. And if the vessel it self be highly refrigerated, either by the cold air, or by having salt and ice applied to the outside of it, the congelation may succeed much the more nimbly; so that within a short while the same liquor, being divers times thawed and frozen again, may possibly exhibit variety of figures. And the production of ice may be also much accelerated, by dipping into the liquor, one would have congealed, the convex surface of some glass or other smooth body, that will not imbibe water; for thereby the depth of the liquor will be exceedingly extenuated, and how much such a thinness or want of depth, may dispose a liquor to be speedily penetrated and congealed by the cold, may be guessed, by what is above delivered in the section out of *Olearius*, of the way of multiplying ice in *Persia*, by making water thinly diffuse it self over a plate of ice, or some other aptly figured, and very cold body: in confirmation whereof, I will add on this occasion, that I have seen a pair of stairs, on which, though they were situated near to three chimneys, commonly furnished with fire, almost all the day long, the water, that was employed to wash them, being thinly spread with a mop, would presently congeal (though they assured me it was hot, when it was begun to be laid on) and cover the stairs with glossy films of ice. And I have likewise observed in a very sharp night, that the water, which dropped down from the nose of a pump, was so well congealed, as it was sliding away, that the ice thus arrested in its passage (in which it will easily be granted that it spreads it self very thinly) had raised a kind of icy pyramid of a considerable bigness and height.

I FORGOT to mention in due places (and therefore think fit to take notice of it here) that when I was considering of the ways, whereby it might be manifested to those, that want nice scales, or distrust their skill to use them, whence that ice comes, that appears on the outside of frozen eggs put to thaw in cold water, I found it somewhat difficult to pitch upon such liquor as I desired. For if common water be the liquor employed, it may be said, that it affords the matter, whereof the ice in question is made: and if I employed liquors, that were spirituous or saline, it might be pretended, that the frost (as they speak) did indeed come out of the frozen egg, though the shell did not appear cased with ice, because as fast as the frost came to the outside of the egg, it was resolved by the spirituous or saline corpuscles of the liquor: wherefore as an expedient, I resolved to make use of oil of turpentine, as a liquor, which

I had found uncongealable by the greatest cold I had observed in our climate, and which yet (as may appear by the third paragraph of the XVIth title) was more indisposed, than common water itself, to thaw any icy efflorescence, that might be emitted by the egg. But the experiment was tried, without uniformity in the successes. For the first time I put a frozen egg into oil of turpentine, I did not observe, that any ice was produced on the outside: neither was the event differing, when another time I put two frozen eggs together into a small vessel full of that oil, though to refrigerate the liquor, the vessel was for a while placed upon a mixture of salt and ice, though also the egg-shells at their gaping cracks (produced by congelation) discovered, that the contained liquor was well frozen. I intended to prosecute the experiment another time (wanting ice to do it then) because that once, when during the trial I was hindered from watching it, one of my domesticks, whom I ordered to look after it, assured me, that the egg, that was put to thaw in the oil of turpentine, had there obtained ice on the outside of it; which I should readily have believed, upon the score of a like observation, I had made my self, in two eggs that were frozen to the bottom of the vessel, wherein they had been put to thaw, were it not, that one or both of them had been, by a mistake, dipt in water, before they were put into the above mentioned oil.

SOME readers may have expected to find, among the examples recited of the influence of cold upon the air, that strange story, which is related by the learned *Josephus Acosta*, of the mountains of *Pariacaca*, (which he several times traversed:*) but besides that I have delivered a great part of it already in another treatise, I was loth to say more, till I had leisure (which I have not now) to discuss the scruples, that I have not so much about the matter of fact, as about the cause, which perhaps may be something besides cold. But since I have mentioned this XVIIIth section, I will here take notice of what I then intended, but forgot to set down; namely, that to the instances alledged to shew the coldness of regions not to be always proportionate to their greater and less vicinity to the pole, we may add a memorable one afforded us by a country so well known to many of us, as *New England*; where, though the winters are so long and bitter, as we have formerly related out of *Mr. Wood's* prospect of that country, (which has been confirmed to me by an American physician, that lived there;) yet that region, which is so much colder than ours, is in many places no less than ten or eleven degrees remoter from the pole.

I SHALL add to the same XVIIIth section, that as to the experiment I there mentioned concerning winds, and which I associate with the testimony of the newly named *Mr. Wood*; I find, that the season of the year, and some other circumstances, may vary it more than one would easily have suspected. For though I faithfully recited the phaenomena, as I then (and that sometimes with witness) took notice of them, yet some months after, and in other weather, having occasion to repeat the former part of that experiment, I was somewhat surprized at the success. For coming to blow upon the ball of a sealed weather glass, which though in its kind very tender, might be probably presumed to be less so, than a thermoscope made with a pendulous drop of water (such as that, mentioned in the forecited paragraph) I found, that if I continued to blow any thing long and briskly, the highly rectified spirit of wine (which circumstance I therefore name, because possibly the nature of that may somewhat alter the case) would sometimes manifestly enough subside. And in that paragraph of the 18th. title, where I recited the experiment of the infrigiding winds, I

* Where a wonderfully piercing, though not sensibly violent cold, does sometimes suddenly kill men, and yet preserve their bodies untainted whole years together.

should.

should more expressly have taken notice of this circumstance, that to satisfy my self, that it was not the bare wind, as such, whose operation upon the air included in the ball of a weather-glass, made the liquor to ascend, we put a mark upon the height it stood at, when we had a pretty while blown upon it; and then, without removing the bellows, put ice and salt about the iron pipe of it. By which mixture the air that was afterwards blown through that pipe, was so cooled in its passage, as to make the liquor very manifestly to ascend, even in a weather-glass, where I did employ (as I have elsewhere declared, that I often do) quicksilver instead of water, or spirit of wine. And lest the vicinity of the frigorifick mixture should be suspected to have caused this contraction of the included air, we did sometimes purposely intermit the moving of the bellows, without removing the weather-glass; and though, notwithstanding that vicinity, the liquor would begin a little to subside; yet when ever the cold spirits, or the corpuscles of highly refrigerated air, were, by the playing of the bellows anew, approached to, or rather brought to touch in swarms the globular part of the instrument, the mercury would manifestly ascend. And since we are speaking of weather-glasses, I shall on this occasion subjoin, that certain circumstances may also vary the success of another experiment (somewhat of kin to that lately repeated, about the pendulous drop) which is briefly mentioned not far from the beginning of the first preliminary discourse. For though the common thermometers, that are here wont to be sold in shops, have usually the pipe of the bolt-head very large in proportion to the ball, and therefore are in that place said to be weather-glasses not nice; and though on such instruments in certain temperatures of the air (intimated by the word *sometimes*, employed in that passage) the air blown out of a pair of bellows against some part of the included air, would not, especially at the beginning, make the air sensibly contract itself, and the liquor ascend; though at the very first and second blast, the coldness of this artificial wind might be very sensible to the touch (which was the thing intended to be taught in that passage) yet having the curiosity with other bellows, at another season of the year, to blow long upon the ball of a not common but nice weather-glass of my own making, furnished with a pipe, that was very slender, I divers times (but not always) found the tinted liquor manifestly enough to ascend, as if the wind, consisting of a more compressed air, did, by containing a greater number of cold particles in the same room, more affect the internal air, than the contact of the calm and lax outward air did before; which disparity of events has given me the design of making further trials with differing thermoscopes, at other seasons of the year, to see if I can bring the matter to some certainty, by discovering the cause of this contingency, in which I afterwards suspected, that some light degree of warmth or coolness in the bellows themselves, which, as being unmanifest to the sense, escaped unheeded, might have an interest. When I was about some of the former experiments, I would willingly have had an opportunity of trying, with a good sealed weather-glass, what difference there would be, betwixt the cold of the nocturnal air in a frosty night, in places, where the air was kept calm, by being sheltered from the wind, not by inhabited buildings, but by some wall, or other body, whence any warm effluvioms were least to be expected; and betwixt the cold of the same air, in places, where cold winds, especially northerly or easterly, did freely and strongly blow. But my occasions then confining me to a town, I had not conveniency to make any secure observations of that nature; and even in a more commodious place, unless it were determined, whether there be corpuscles properly and constantly frigorifick, upon whose account some winds are so much colder than others, there may arise more scruples about this matter, than I must now stay to discuss.

THERE

THERE is one thing more, that, it may be, is not impertinent to mention, before I take leave of the XVIIIth title: for in confirmation of what is there delivered, concerning the vicissitudes of these troublesome degrees of cold and heat, within the compass of the same natural day, complained of by the patriarch *Jacob*, and by *Olearius*, I shall add, that having since had opportunity to inquire about such matters of a learned physician, lately come from the *Indies*, he assured me, that notwithstanding the violent heats of the day, he usually observed the nights to be so very cold, that he was positive some frigorifick steams did, in the night, ascend out of the earth, and make it very expedient, if not necessary, for those English, that live in the warmer parts of *America*, to imitate the natives, in keeping fires under their hammocks, or hanging-beds.

I THOUGHT it might be a luciferous experiment, in relation to an hypothesis, that might be proposed about cold, to try, whether, if two such liquors were provided, as by being mixed together, would so far forth lose their fluidity, as to obtain at least the consistency of an unguent, this impediment, put to the former confused and greater agitation of their parts, would produce any sensible degree of cold; this I thought fit to try, by immersing, for a competent time, the ball of a tender sealed weather-glass into each of the liquors apart, and then into the soft mixture, their coalition would compose. To produce such a mixture more ways than one, it was not difficult for me, by the help of some experiments, I had provided to add to my *History of Fluidity and Firmness*. But though a strong solution of minium (or calcined lead) in spirit of vinegar, or a very strong infusion of good quick-lime in water, will either of them (and one of them I did make use of, though I have forgotten which) coagulate a just proportion of good salad-oil (to name no other made by expression) into such a consistence as I have been speaking of; yet for want of a sealed thermometer, tender enough, I cannot now repeat the experiment, and till I do, I dare not draw any experiment from it; though, if I much misremember not, when I shewed it an ingenious person, neither he nor I could perceive, that the liquors, by being deprived of their fluidity, had acquired any thing of coldness discoverable by the sealed weather-glass.

It is much controverted among the curious, whether water be capable of compression; and divers have of late inclined to the negative, upon observing a want of cogency in the experiments, that have been brought to evince the affirmative. What trials and observations we long since made about this matter, may be met with in some of our other treatises, wherefore I shall now subjoin, that having imagined, that cold might afford a hopefuller way, than (for aught I know) any man has used, of bringing this controversy to the decision of an experiment, I made that attempt, that is mentioned in the XIIth title; in prosecution of which, as soon as I could procure some, though but some of the accommodations, which I long wanted, I made an experiment, which I shall subjoin, because though it be not so considerable, as with better implements I could have made it, yet the way I chose, has (as I partly intimated elsewhere) these two advantages; that the force employed to compress the air, is both very great, and very gradually, and slowly applied; and that the vessel will not, like those, that have been hitherto made use of, give any passage through its pores to water, though violently compressed.

WE took then a round ball of glass, furnished with a moderately long pipe, and having filled it with water, till the liquor reached within some inches of the top, it was hermetically sealed up, and then the water, by a mixture of beaten ice and salt, was made to freeze from the bottom upwards; and that without breaking the glass, the unfrozen water, by the expansive endeavour of that which was freezing, might be

impelled upwards; and so at once both compress the air, and be pressed upon by it, having by this means condensed the air, as far as we thought safe to do in a glass, that was not strong, we cropt off the small apex of the glass, and immediately the compressed air flew out with a great noise, and that part of the pipe which was unfilled with water, was filled with smoke, that made it look white, and great store of little bubbles hastily ascended from the lower parts of the water, to the upper (where most of them quickly broke) in such a way, as put me in mind of what usually happens upon the opening of vessels that contained bottled beer. But that, which was principally to be noted, was this, that besides the bubbles or froth, the water itself (at least supposing, that no little unheeded bubbles, that did not quite emerge, could sensibly contribute to its height) immediately ascended in the pipe about $\frac{3}{4}$ of an inch, which (having carefully marked the first and second stations, with a diamond on the outside of the glass) it was easy for us to measure.

I HAVE elsewhere proposed a suspicion, that in the attempts, that had been till then made, to compress water, the condensation (in case there were really any) might perchance proceed from the compression of the aerial particles, that I have shewn to be wont to lie dispersed in the pores of common water. But though the considerable expansion of water, notwithstanding the breaking of the bubbles in our present experiment, seems manifestly to argue, that this could be but a concurrent cause (if it had any sensible effect at all) of our phænomena, yet I dare not absolutely rely, even upon an experiment, that seems so cogent, till I have satisfied myself, that no springiness, which I have sometimes suspected might be in the ice, had any interest in the produced effect; and that the great pressure of the forcibly condensed air, did not make the glass itself stretch or yield. For if it were able to do so, then the parts of the violently distended glass, upon the removal of the forcible pressure of the air (which must cease upon the breaking of the hermetical seal) returning to their former straitness below, will make the water ascend somewhat higher in the pipe. But though I could not procure glasses, as well very thick, as conveniently shaped, wherewith to examine this suspicion, which I likewise would have tried by the bulk of the glass in water, before and after the letting out of the compressed air; yet because most readers will probably think so much caution more than necessary, I shall add, that if I had not wanted conveniencies, and had not had mischances, the experiment would, in likelihood, have been advanced; especially care being taken, that the air left in the pipe should be well refrigerated before its being sealed up, (as we sometimes did by ice and salt, applied in a perforated box to the outside) lest part of its spring should depend upon an evanid degree of heat; upon which account the pipe ought before-hand to be drawn so slender, that the glass may be melted together in a trice. For though for want of strong glasses, and the best sort of instruments to seal up such with, the success was not still so considerable as I hoped for; yet as four or five other trials, made, as well with another liquor, as with water, did exhibit a manifest intumescence of the liquors (without computing the froth produced at the top); so in the experiment lately mentioned, if we had judged them strong enough to endure such a compression of the included air, as we have often made on other occasions, the effect would probably have been much more considerable. For though the difference betwixt the length of the same water compressed and uncompressed amounted to an aqueous cylinder of $\frac{3}{4}$ of an inch in height, yet the air, that made this compression of the water, was itself reduced but from eight inches to five; so that it took up almost half its former room, whereas we have sometimes reduced it to an 18th or 20th part thereof. If I had been accommodated with one of my pneumatical engines, I should have tried, whether water being first carefully freed from the latent

air

air in the exhausted receiver, and then compressed after the manner hitherto recited, the event of the trial would have been considerably varied.

I MIGHT add, as other phænomena of our experiment, that when we broke off the sealed apex of the glass, before the included air was much compressed, there neither would be any great noise made, nor any considerable froth produced, at the top of the water; and that having had the curiosity to repeat the experiment in one of the same glasses, that had been already used and with the same water, that had been already compressed in it, we found, that upon the breaking off the hermetical seal the second time, the water did nevertheless ascend into the pipe betwixt $\frac{1}{8}$ and $\frac{1}{4}$ part of an inch. And to these particulars I could both add other circumstances, that I took notice of in the same experiment, and subjoin many other experiments and observations, but that I am already tired. And though I have not found cold to be a subject over-fruitful in experiments pleasing and curious, yet now I am grown somewhat acquainted with it, I find it may suggest so many other new ones, that since the barrenness of my theme will not easily put a period to this treatise, it is fit that now at length I should let my weariness and want of leisure do it.

A N

EXAMEN of ANTIPERISTASIS,

A S

It is wont to be TAUGHT and PROVED.

THEMISTIUS, CARNEADES, ELEUTHERIUS.

THEMISTIUS.

1. **A**S for *Antiperistasis*, the truth of it is a thing so conspicuous, and so generally acknowledged, that I cannot imagine what should make some men deny it, except it be, that they find all others to confess it. For though in other cases they are wont to pretend experience for their quitting the received opinions, yet here they quit experience itself for singularity, and chuse rather to depart from the testimony of their senses, than not to depart from the generality of men.

2. AND to evince, that this is not said *gratis*, I might observe to you, that there are no less than three grand inducements, that have led both the vulgar and philosophers (two sorts of men, that seldom agree in other things) to consent in the acknowledgement of *Antiperistasis*; authority, reason, and experience. But though I think fit to name them all three, yet since the first of them, by having, as I just now noted, invited our adversaries to dissent from the truth, is a somewhat unlikely medium to prevail on them to acknowledge it, I shall insist only on the two latter; having once declared, that I lay aside the first, not as worthless in it self, but needless to my cause.

3. To begin then with the arguments afforded us by reason.

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WHAT can there be more agreeable to the wisdom and goodness of nature, who designing the preservation of things, is wont to be careful of fitting them with requisites for that preservation; than to furnish cold and heat with that self-invigorating power, which each of them may put forth, when it is environed with its contrary. For the order of the universe requiring, that cold and heat should reside in those bodies, that often happen to be mingled with one another, those two noble and necessary qualities would be too often destroyed in the particular subjects, that harboured them, if provident nature had not so ordered the matter, that when a body, wherein either of them resides, happens to be surrounded by other bodies, wherein the contrary quality is predominant, the besieged quality, by retiring to the innermost parts of that, which it possesses, and thereby recollecting its forces, and as it were animating it self to a vigorous defence, is intended or increased in its degree, and so becomes able to resist an adversary, that would otherwise easily destroy it.

4. To illustrate as well as supply this argument drawn from reason, we shall need but to subjoin the other afforded us by experience, which does almost every day give us not only opportunity to observe, but cause to admire the effects of this self-invigorating power, which, when occasionally exerted, we call Antiperistasis: and these phænomena ought the more to be acquiesced in, because they may safely be looked upon as genuine declarations, which nature makes of her own accord, and not as confessions extorted from her by artificial and compulsory experiments, when being tortured by instruments and engines, as upon so many racks, she is forced to seem to confess whatever the tormentors please.

5. To proceed then to the spontaneous phænomena of nature I was recommending, we see, that whereas in summer the lowest and highest regions of the air are made almost unsufferable to us by their heat, the cold expelled from the earth and water by the sun's scorching beams retires to the middle region of the air, and there defends it self against the heat of the other two; though in the one, that quality be assisted by the almost perpendicular reflection of the sun-beams, and in the other it be rendered very considerable by the vastness of the upper region of the air, and its vicinity to the element of fire.

AND as the cold maintains itself in the middle region, by virtue of the intenseness, which it acquires upon the account of Antiperistasis; so the lightening, that flashes out of the clouds, is but a fire produced in that middle region, by the hot exhalations penned up, and intended in point of heat by the ambient cold, to a degree, that amounts to ascension.

6. BUT though these be unquestionably the effects of that excessive coldness; yet we need not go so far as the tops of mountains to fetch proofs of our doctrine, since we may find them at the bottom of our wells. For though *Carneades* perhaps will not, yet the earth as well as the air doth readily acknowledge the power of Antiperistasis. And if the reason above alledged did not evince it, our very senses would. For as in summer, when the air about us is sultry hot, we find, to our great refreshment, that the air in cellars and vaults, to which the cold then retreats, is eminent for the opposite quality; so in winter, when the outward air freezes the very lakes and rivers, where their surfaces are exposed to it, the internal air in vaults and cellars in winter, which becomes the sanctuary of heat, as in summer it was of cold, is able not only to keep our bodies from freezing, but to put them into sweats. And not only wells and springs, upon the account of their resting in, or coming out of the deepest parts of the earth, continue fluid, whilst all the waters, that are contiguous to the air, are by the excessive cold hardened into ice; but the water freshly drawn from such wells feels warm, or at least tepid to a man's hand put into it. And as if nature
designed

designed men should not be able to contradict the doctrine of Antiperistasis, without contradicting more than one of their own senses, she has taken care, that oftentimes the water, that is freshly drawn out of the deeper sorts of wells and springs, should manifestly, as I have seen it, smoke, as if it had been but lately taken off the fire. And this may be said, without a metaphor, to demonstrate *ad oculum* the reality of Antiperistasis; there being no other cause, to which this warmth can be attributed, than the retiring of the heat from the cold external air to the lower parts of the earth and water; since both these elements themselves being naturally cold, and one of them in the supreme degree, the heat we are mentioning, is so far from being likely to be generated in so unfit a place, that, if it were not very great, it must be extinguished there, by the coldness of the superiour air, and that of the inferiour parts of the earth.

ELEUTHERIUS. 7. That *Carneades* may have but one trouble, to answer the allegations to be made in favour of Antiperistasis, I hope he will give me leave, (according to my custom of siding with either party, as occasion invites me) to add to the familiar observations mentioned by *Themistius* some others, that are less obvious. For I frankly confess to you, that when I consider, what interest the unheeded dispositions of our own bodies may have in the estimates we make of the degrees of cold and heat, in other bodies; I should not lay much weight upon the phænomena, that are wont to be urged as proofs of Antiperistasis, if some instances, somewhat less liable to suspicion, did not countenance the doctrine they are urged for. I know, that *Carneades* being wont so to propose his opinion about Antiperistasis, as only to deny, that it is clearly made out by the reasons or experiments, that are commonly produced to evince it, it were somewhat improper to urge him with observations, that are not familiar, and wont to be employed; but I know too, that he is not so rigid an adversary, as not to allow me to mention some uncommon relations, that I learned from men of good credit. I shall tell you then, that having purposely inquired of ingenious men, that had been very deep under ground, some in coal-pits, and some in mines; one of them affirmed, that, at the bottom of the grove (as they call it) or pit, he found it very hot in *September*. And another, that he often found it hot enough, to be troublesome in winter. And a third, (who is himself a great seeker for mines, and a master of considerable ones) that he found it to be hot all the year long. And to manifest, that such observations will hold even in gelid regions, I shall repeat to you, what I remember I read in the voyage of that ingenious navigator, Captain *James*; who, giving an account of *Charleton Island*, which, by his relation, seems to be as cold as *Iceland* itself, says, (pag. 36.) *That his men found it more mortifying cold, to wade through the water in the beginning of June, when the sea was full of ice, than in December, when it was increasing.* And he adds, that which makes more to our present purpose, and proves the other part of the doctrine of Antiperistasis; *That, from their well, out of which they had water in December, they had none in July.* And, to strengthen the observation yet further, I will acquaint you with a relation to this purpose, not unworthy your notice: for, hearing of an ingenious physician, that lived some years in and about *Moscow*, I applied myself to him, (as possibly you may have done; for, if I mistake not, I have seen you together) to know, whether, in that frozen region, he observed the cellars to be hot in winter. And his answer to that, and some other questions of the like nature I put to him, amounted in short to this; that when I inquired, whether their springs and wells were not all frozen in the winter, he told me, that he saw some springs, whose waters froze not at all near the spring-heads, but, at a good distance from thence, it began to be thinly cased over with ice. He added, that his own well was about six fathoms deep, between the surface of the earth, and that of the water, and that the water in it was, as I remember,

remember, about three or four fathoms deep; and that not only this well froze not all the winter, but that the well of his neighbour, which was but one fathom deep to the superficies of the water, did not freeze neither. And, to satisfy my curiosity about the steams of this water, he told me, that when a bucket of water was newly drawn, if it were agitated, it would smoak; but that, from the well itself, when the water in it was left quiet and unstirred, he did not perceive any smoak to arise.

8. To all this, I shall add this further circumstance, that, having purposely inquired, whether, in the winter, he found it as hot in cellars at *Moscow*, as it is wont to be, in that season, in our's? he answered me, that when the doors and windows were carefully shut, to hinder the immediate commerce betwixt the included and external air, he often found, if he stayed long in his cellar, it would not only defend him from the sharpness of the Russian cold, as bitter as that is wont to be in winter, but keep him warm enough, to be ready to sweat, though he laid by his furs. So that, if we may rely upon the testimony of our senses, we must necessarily admit cellars to be warmer in winter, than in summer, and consequently allow an Antiperistasis.

CARNEADES. 9. Though I were not in haste, I should not think it necessary to reply any thing else to the first part of what was said by *Themistius*, than that, what he alledges of the universality of the opinion he maintains, may serve to recommend that, which he opposes. For the vulgar doctrine about Antiperistasis being, as he urges, received and taught in all the schools, the innovators, he declaims against, must have learned it there, among the other Peripatetick tenents, that youth is wont to be imbued with in those places; so that it may rather seem the love of truth, than of singularity, that engages them against an opinion, which before was their own, as well as that of the generality of scholars; and consequently, against which they cannot maintain a paradox, that does not imply a retractation. But I shall not prosecute my answer to *Themistius's* preamble, since *Eleutherius*, whom I am chiefly to speak to, is too much a philosopher, to think truth less herself, for being slenderly attended; or to think any men the less like to be her followers, because they are but few. To come then directly to the controversy itself, I think, I need not tell one of you, that the other mistakes my opinion about it. For I perceive, *Eleutherius* hath not quite forgotten, that I have not been wont to deny an Antiperistasis, as it may be, but only as it was wont to be, explicated. But since *Themistius* seems to be willing to have me his antagonist in this controversy, and since *Eleutherius* himself seems to conspire with him, I am content to act, for a while, the part, you gentlemen would have me take upon me, and will propose to you part of what I would say for the opinion you impute to me, in case I were really of it.

10. To come then to the controversy itself, though *Themistius* has drawn his proofs for the Antiperistasis of the schools, partly from reason, and partly from experience; yet the very same two topicks seem to me to afford considerations, that may justly warrant our calling it in question.

11. AND first, if we look upon the reason of the thing, considered abstractedly from the experiments, that are pretended to evince an Antiperistasis, we cannot but think, it may be very rational, I say not, to doubt of it, but to reject it. For, in the first place, according to the course of nature, one contrary ought to destroy, not to corroborate, the other. And next, it is a maxim among the Peripateticks themselves, that natural causes always act as much as they can. And certainly, in our case, wherein we treat not of living creatures, I cannot but think the axiom physically demonstrative. For inanimate agents act not by choice, but by a necessary impulse; and, not being endowed with understanding; and will, cannot of themselves be able

to moderate or to suspend their actions. And as for what *Themistius* alledges, that it was necessary for the preservation of cold and heat, that they should be endowed with such a power of intending themselves, I must freely confess, that though, in living creatures, and especially in the bodies of the perfecter sorts of animals, I do, in divers cases, allow arguments drawn from final causes; yet where only inanimate bodies are concerned, I do not easily suffer myself to be prevailed upon, by such arguments. Nor is there any danger, that cold and heat, whose causes are so radicated in nature, should be lost out of the world, in case each parcel of matter, that happens to be surrounded with bodies, wherein a contrary quality is predominant, were not endowed with an incomprehensible faculty of self-invigoration. And nature either does not need the help of this imaginary power, or oftentimes has recourse unto it to very little purpose: since we see, that these qualities subsist in the world, and yet, *de facto*, the bottles of water, wine, and other liquors, that are carried up and down in the summer, are regularly warmed by the ambient air. And in *Muscovy*, and other cold northern countries, men, and other animals, have oftentimes their vital heat destroyed by the cold, that surrounds them, being thereby actually frozen to death. And I somewhat wonder, that the followers of *Aristotle* should not take notice of that famous experiment, which he himself delivers, where he teaches, that hot water will sooner congeal than cold. For, if the matter of fact were true, it would sufficiently manifest, that the heat harboured in the water is destroyed, not invigorated, by the coldness of the air, that surrounds it; so that *Themistius* must, I fear, on this occasion, take sanctuary in my observation; and, to keep *Aristotle* from destroying his own opinion, with his own experiment, had best say, as I do, that it is not true. And though it is not to be denied, that white surrounded with black, or black with white, becomes thereby the more conspicuous; yet it is acknowledged, that there is no real increase, or intensification, of either quality, but only a comparative one, in reference to our senses, obtained by this collation. Nor does a pumice-stone grow more dry than it was in the fire or earth, by being transferred into the air or water, and consequently environed with either of those two fluids, which *Themistius* and his schools teach us to be moist elements; neither will you expect to find a piece of dim glass become really more transparent, though one should set it in a frame of ebony, though that wood be so opacous as to be black. And whereas it is commonly alledged, as a proof of the power, nature has given bodies, of flying their contraries, that drops of water falling upon a table will gather themselves into little globes, to avoid the contrary quality in the table, and keep themselves from being swallowed up by the dry wood; the cause pretended has no interest in the effect, but little drops of water, where the gravity is not great enough to surmount the action of the ambient fluid, if they meet with small dust upon a table, they do, as they roll along, gather it up, and their surfaces being covered with it, do not immediately touch the board, which else they would stick to. And to shew you, that the globular figure, which the drops of water, and other liquors, sometimes acquire, proceeds not from their flying of dryness, but either from their being every way pressed, at least almost equally, (for in some cases also they are not exactly round) by some ambient fluid of a disagreeing nature, or from some other cause, differing from that the schools would give; I shall desire you to take notice, that the drops of water, that swim in oil, so as to be surrounded with it, will likewise be globular; and yet oil is a true and moistening liquor, as well as water. And the drops of quicksilver, though upon a table they are more disposed, than water, to gather themselves into a round figure; yet that they do it not as humid bodies, is evident, because quicksilver, broken into drops, will have most of them globular, not only in oil but in water. And to shew you, that it is from the incongruity it has to certain bodies,

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Fluidity,
Sect. 19.

bodies, that its drops will not stick upon a table, nor upon some other bodies, but gather themselves into little spheres, as if they designed to touch the wooden plain but in a point; to manifest this, I say, we need but take notice, that though the same drops will retain the same figure on stone or iron, yet they will readily adhere to gold, and lose their globulosity upon it, though gold be a far drier body than wood, which, as far as distillation can manifest, must have in it a store of humid parts of several kinds, (I mean both watery and unctuous.) But this may relish of a digression; my task being only to examine the Antiperistasis of cold and heat, concerning which, I think, I had very just cause to pronounce the vulgar conceit very unconsonant to the nature of inanimate beings. For the Peripateticks talk of cold and heat surrounded by the opposite quality, as if both of them had an understanding, and foresight, that, in case it did not gather up its spirits, and stoutly play its part against the opposite, that distresses it, it must infallibly perish; and as if, being conscious to its self of having a power of self-invigoration, at the presence of its adversary, it were able to encourage itself, like the hero in the poet, that said,

Nunc animis opus est, Ænea, nunc pectore firmo.

Which indeed is to transform physical agents into moral ones.

ELEUTH. 12. The validity of the Peripatetick argument, drawn from reason, considered abstractedly from experience, I shall leave *Themistius* to dispute out with you, at more leisure. And since you well know, that the only arguments I alledge to countenance Antiperistasis, were built upon experience, as judging them either the best, or the only good ones, I long to hear what you will say to the examples, that have been produced of that, which you deny.

CARNEADES. 13. That *Eleutherius*, which I have to answer to the examples, that are urged, either by the schools, or by you, in favour of Antiperistasis, consists of two parts. For, first, I might shew, that, as reason declares openly against the common opinion, so there are experiments, which favour mine, and which may be opposed to those you have alledged for the contrary doctrine. And, secondly, I might represent, that of those examples, some are false, others doubtful; and those, that are neither of these two, are insufficient, or capable of being otherwise explicated, without the help of your hypothesis. But, for brevity's sake, I shall not manage these two replies apart, but mention, as occasion shall serve, the experiments, that favour my opinion, among my other answers to what you have been pleased to urge on the behalf of *Aristotle*.

14. To begin then with that grand experiment, which, I remember, a late champion for Antiperistasis makes his leading argument to establish it, and which is so generally urged on that occasion; I mean, the heating of quick-lime in cold water: I confess, I cannot but admire the laziness and credulity of mankind, which have so long, and generally, acquiesced in what they might so easily have found to be false. This I say, because I was possibly the first, that has had both the curiosity and boldness to examine so general and constant a tradition; yet I doubt not, that you will soon be brought to take it, as well as I, for as great, as popular, an error. For, to let you manifestly see, how little the incalcescence of the quick-lime needs be allowed to proceed from the coldness of the ambient water, if, instead of cold water, you quench it with hot water, the ebullition of the liquor will not only be as great, as if the water were cold, but oftentimes far greater. As I have sometimes, for curiosity, removed boiling water from the fire; and when the liquor had left off boiling, but was yet scalding hot, I put it into a convenient quantity of quick-lime; and, after a while,

while, the water, which, as I said, had ceased from boiling, began to boil afresh, with so much vehemence, and such large and copious bubbles, that it threatened to run over the pot, of which, before the effervescence, a considerable part was left unfilled. And this was no more, than what I might well look for, hot water being much fitter than cold, to pervade nimbly the body of the lime, and hastily dissolve, and set at liberty the igneous and saline parts, wherewith it abounds. And how much a greater interest salts may have in such incalescencies, than cold, I have also taken pleasure to try, by pouring acid spirits, and particularly spirit of salt, upon good quicklime. For, by this means, there would be a far greater degree of heat excited, than if I had, instead of spirit of salt, used common water; and this, whether I employed the spirit cold or hot. For in either case, so small a portion, as about the bigness of a walnut of lime, put into a small glass, would, by the addition of a little spirit of salt, put to it by degrees, both hiss and smoak, and boil very surprizingly; and, notwithstanding the small quantity of the matter, would conceive so great a heat, that I was not able to hold the glass in my hand. And to shew some friends, how little heat excited in quick-lime by cold water proceeds barely from the coldness of that liquor, I caused a parcel of good lime to be beaten small, and putting one part of it into a glass vessel, I drenched it plentifully with oil of turpentine, more than it would imbibe, and the other portion of the lime I likewise drenched with common water: both these liquors having stood in the same room, that they might be reduced by the same ambient air, to a like degree of coldness, the event of this trial was (what I looked for) that the oil of turpentine, notwithstanding its actual coldness, and the great subtilty and piercingness of parts, which it has in common with other chymical oils, being of an incongruous texture, seemed not to make any dissolution of the powdered lime, and did not, for several hours, that I kept it, produce, that I perceived, any sensible heat in the lime. Whereas, to shew, that it was not the fault of the lime, that part of it, on which common water had been poured, did, after a little while, conceive so strong a heat, that it broke a large open-mouthed glass, into whose bottom it was put; and not only grew so hot, that I could not endure to hold it in my hand, but sent out at the mouth of the glass, though that were considerably distant from the lime, a copious white fume, so hot, that I could not well suffer the holding of my hand over it. And, to prevent a possible, though invalid objection, which I foresaw might be drawn against the experiment made with oil of turpentine, from the oleaginous nature of that liquor, I covered a piece of the same sort of quicklime, I have been speaking of, with highly rectified spirit of wine: but though I left them together all night, yet I perceived not, that the liquor had at all slackened the lime, which continued in an entire lump, till, upon the substituting of common water, it did, as I remember, quickly appear to be slackened, since it fell asunder into a kind of minute white powder, which was (bating the colour) almost like mud, and would easily, by a little shaking, be dispersed, like it, through the water.

ELEUTHERIUS. 15. I ingenuously confess to you, *Carneades*, that what you say surprizes me; for I thought it superfluous to try my self so acknowledged an experiment, being not able to imagine, that so many learned men, for so many ages, should go unanimously, and confidently, deliver a matter of fact, of which, if it were not true, the falsity could be so easily discovered.

CARNEADES. 16. For my part, *Eleutherius*, I confess, I am wont to doubt of what they teach, that seldom or never doubt. And I hope you will forgive me, if, having found an assertion so general and uncontrouled, of a falsity so easy to be disproved, I be inclinable to suspect the truth of their other inferior traditions about

Antiperistasis; and of these I will mention the two chiefest I have met with among the moderns, (for being contrived experiments, I presume you will easily believe, they came not from *Aristotle*, nor the ancient schoolmen, that commented upon him.)

17. THE first of these is the freezing a pot to a joint stool, by a mixture of snow and salt, by the fire's side; in which case it is pretended, that the fire does so intend the cold, as to enable it to congeal the water, that stagnated upon the surface of the stool, betwixt that and the bottom of the pot. But how little need there is of Antiperistasis in this experiment, you may guess by this, that I have purposely made it with good success in a place, in which there neither was, nor ever probably had been, a fire, the room being destitute of a chimney. And this trial of mine I could confirm by divers other experiments of the like nature, but that this one is sufficient.

18. I PROCEED therefore to the other experiment, which is delivered by very learned men, and for whom I have a great respect: according to these, if you take a somewhat large pot, and having filled it almost with snow, place in the middle of the snow a phial full of water; this pot being put over the fire, the coldness of the snow will be so intended by the heat, from which it flies into the water, that it will turn that liquor into ice. But though I several times tried this experiment, yet neither in earthen, nor in silver vessels, could I ever produce the promised ice. And I remember, that an eminently learned man, that wondered to find me so diffident of what he said, he knew to be true, readily undertook to convince me, by an ocular proof; but with no better success, than I had before. So that the argument may be plausibly enough retorted upon them, that urge it.

19. AND in case the trial should succeed some time or other, (for that it doth not ordinarily, I have shewn already) yet will there be no necessity of deriving the effects from Antiperistasis. For though, in such cases, the fire would contribute to the production of the effect, by hastening the dissolution of the snow; yet the heat of the fire does but remotely, and by accident, cause the production of ice, since other agents will do the same thing, that are qualified to make a quick dissolution of the snow, whether they be hot or no; as I have tried, that spirit and crude salt of nitre will either of them, by a due application, bring snow, by dissolving it, to congeal water, though the spirit and the nitre be generally agreed upon to be actually cold, and one, if not both of them, to be potentially cold too.

20. HAVING thus dispatched the experiments, pretended to evince an Antiperistasis, I must now examine the observations, that are alledged to that purpose, of which the principal, if not the only, are these; the coldness of the middle region of the air; the increase of mens stomachs in winter; the generation of hail; and the heat and cold in cellars, and other subterranean places, when the contrary quality reigns in the air.

21. To begin with the first of these: I will not now dispute, whether the second region of the air have really that coldness, that is wont to be ascribed to it; though our friend Mr. *Boyle* seems to doubt, whether that region's being always and every where cold, hath been as strongly proved, as asserted. But passing over that question, I see no need of imploring the help of Antiperistasis, to keep the second region of the air for the most part cool. For without at all taking in the cause imagined by the schools, an obvious and sufficient one may be easily assigned. For the air being, as to sense, cold of its own nature, so that when we feel it hot, it is made so by some adventitious agent; and that agent being for the most part the sun, who heats the air chiefly, though not only, by its reflected beams; their heat is so languid, by that
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time they arrive, disperfed, at the fecond region of the air, that they are not able to overpower its natural coldnefs, increafed perchance by fome frigorifick fpirits, that may find a more commodious harbour there, than in other parts of the atmofphere. And whatever be the true caufe of the coldnefs in the middle region of the air, I cannot but admire to find that coldnefs fo confidently afcribed to Antiperiftafis, by *Themiftius* and his friends the *Aristotelians*: for, according to them, it is the nature of the element of air to be as well hot as moift, and according to the fame *Peripateticks*, both the upper region of the air always, and the lower in fummer is hot: the former by the neighbourhood of the imaginary element of fire, and the latter by the reflexion of the fun-beams from the earth: which two pofitions being laid together, I would fain learn of any *Aristotelian*, how Antiperiftafis comes to take place here? For, according to them, thofe bodies have their cold and heat increafed by Antiperiftafis, that are on both hands affailed by bodies of a contrary quality, to that which is natural to the furrounded body: whereas the whole element of air, and confequently the middle region, being, as they would perfuade us, hot, of its own nature; what fhadow of probability is there, that the higheft and loweft regions, by being hot, fhould make the middle region, which is alfo naturally hot, intenfely and durably cold? But though the objection is fo clear, that it needs not to be infifted on; yet, becaufe it is but an argument *ad hominem*, I fhall add this, for their fakes, that are not in this point *Peripateticks*: that it does not appear to me, that if the air be naturally rather cold than hot, the fecond region muft owe the intenfenefs of that quality to an Antiperiftafis. For the ground of the opinion, I oppofe, being this, that both the firft and the third regions are confiderably hot, I would gladly find it proved as to the upper region. I confefs, I have not found the affertion contradicted; but that as little convinces me, as the uncontrolednefs of the tradition about quicklime, that I lately confuted. It is true, there are two reafons alledged, to evince the heat of the fupreme region of the air, but neither of them to me feems cogent. For the firft is, that the vicinity of this region to the element of fire makes it partake a high degree of heat. But if we confider the diftance of that element, which they place contiguous to the orb of the moon, and how little nearer to it the concave part of the upper region is, than the convex of the middle, we may eafily conceive, that in two diftances, that are both of them fo immense, fo fmall a difparity cannot be much (if at all) more confiderable, than the greater nearnefs of one fide of a fheet of paper, held at three yards diftance from an ordinary fire, in comparifon of the diftance of the other fide of the fame paper; or than the diftances of a fmall wart, and of the neighbouring parts of the face, when a man comes within two or three yards of the fire. But it is not worth while to profecute this confideration, becaufe the argument againft which it is alledged, is built upon the groundlefs fuppofition of the element of fire, a figment, which many of themfelves do daily grow afhamed of, as indeed its exiftence is as little to be difcovered by reafon, as perceived by fenfe.

22. THE other argument for the heat of the third region of the air is, that fiery meteors are kindled by it. But not now to queftion, whether all meteors, that fhine, and therefore pafs for fiery, are really kindled exhalations; we fee, that in the lower region of the air, and in winter, thofe fires, which are called either *Helena*, or *Cafter* and *Pollux*, are generated in great ftorms, and hang about the fails and fhrouds of fhips. Nay, do we not much more frequently fee, that lightning is produced at all feafons of the year? for in warmer countries thoufands have obferved it to thunder (and fo have I in winter) in the middle region of the air. And fince it is not the heat of the inferiour part of the air, that kindles thofe exhalations; and if

notwithstanding the coldness of the second region, fiery meteors may be frequently generated there; I see no reason why the production of such meteors should argue the heat of the third region of the air. And if that region be not hot, then it will, I presume, be easily granted, that the coldness of the second must very improperly be attributed to such an Antiperistasis, as it is generally ascribed to.

23. I COME next to consider that aphoristical saying of *Hippocrates*, *Ventres hyeme esse calidiores*, together with the observation, whereon it seems to have been grounded. I will not now examine, whether any arguments for the contrary may be drawn from the heat and thirst men feel in summer, and the refreshment they then find by drinks and fruits, and other aliments that are actually cold. For that, which I principally intended to say, is this, that I much more doubt the matter of fact delivered in the aphorism, than that, in case it be true, it may be made out without the help of Antiperistasis, in the vulgar and scholastic notion of that term.

24. I CONSIDER then first, that the proof, that is wont to be brought of the greater heat of men's stomachs in winter, is, that men are wont to have then a greater appetite to their meat. But though I pay so much respect to the great *Hippocrates*, as to allow the aphorism in a sense; yet I admit it to be true but upon an hypothesis, that I do not admit to be so. For the aphorism supposes, that the digestion of meat in the stomach is made by heat; and consequently, that the stronger digestion, that is wont to be made in winter, is an argument of the stomach's being then hotter, than at other seasons of the year. But the erroneousness of this supposition, I think, I need not solemnly prove to *Eleutherius*, who, I doubt not, has taken notice of several things in nature, that agree not with it, and particularly of the strong concoction, that is made in the stomachs of divers ravenous fishes, whose stomachs and blood are yet, as I have purposely observed, sensibly cold: but if it should in some cases prove true, that there is really in men's bodies a far greater heat in winter than in summer, yet this would not infer an Antiperistasis in the sense, wherein I oppose it. For the vital heat lodged in the heart, always generating out of the blood and juices, that continually circulate through that part, great store of spirits and warm exhalations, which are wont to transpire through the pores of the skin in much greater quantities, than, notwithstanding the affirmations of *Sanctorius*, any thing but my own trials could have persuaded me; these warm steams finding the pores of the skin straitened and shut up, grow more and more copious in the body, and thereby heat the stomach, as well as the other internal parts of it: and perhaps also the same frigorifick corpuscles or temperature of the air, that produce cold in winter, may, by shutting in certain kinds of effluvia, or perhaps altering the motion or texture of the blood, reduce it to such a disposition, as that the appetite shall be increased, as well as the concoction in the stomach promoted by the stomachical menstruum, or ferment, which either is newly generated in winter, or more copiously supplied (by the circulating of the blood to the stomach) in that season than in others. And to shew, that a good appetite may be procured by agents endowed with very distinct and contrary qualities; do not we see, that spicy sauces, wine and vinegar, do all of them, in most men, beget an appetite, though the two former be confessedly hot, and the latter cold? And so wormwood and juice of lemons have both of them frequently relieved dull and weak stomachs, though the one be confessedly a hot simple, and the other a cold. And in some cases either the frigorifick corpuscles themselves, and perhaps some other unknown to us, that they may bring along with them, may so solicit the stomach, as to breed an eager appetite, not precisely by their being cold or hot, but
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by their peculiar nature; as we have instances of some, that in these parts by walking on the snow, procure to themselves a bulimia. And the learned *Fromundus* relating, how he himself, by walking along on the snow, was surprized with such a *Bulimia*, takes notice, that the chief cause of the fainting was in the stomach; and that he found by his own experience, that that part was discomposed, convelled, and provoked to cast. To which he adds, (what makes much for my present purpose) that he thinks now the chief cause of the bulimia to consist in certain steams, that do peculiarly affect the stomach, which they gnaw and distend. And just before he observes, that straining to fetch deep coughs is a present remedy in this distemper, by discharging the stomachs and lungs of those snowy spirits, which were either attracted in respiration, or had some other way insinuated themselves in those parts: so that besides the cold abstractedly considered, the stomach may be peculiarly affected by other, either attributes or concomitants, of the frigidifick corpuscles, that grow powerful in frosty weather; with which it well agrees, that divers have been observed to be subject to bulimias in these parts of the world, though in our warmer climates such men endure nothing near so great a cold, nor are so much inconvenienced by it, as multitudes of others, that in *Nova Zembla*, and other gelid regions, never complained of having contracted, even in the midst of winter, any such disease.

25. ANOTHER argument, that is specious enough, urged in favour of Antiperistasis, is borrowed from the production of hail, which is presumed to be generated in summer only, not in winter; and, according to *Aristotle*, and the schools, is made in the lowest region of the air, by the cold of the falling drops of rain so highly intended by the warmth it meets with in the air near the earth, as to congeal the water, wherein it is harboured. But though I freely confess to you, that I think the generation of hail difficult enough to be solidly explicated; yet I scruple not to reject the received doctrine about it, for several reasons, of which I will now name four.

26. FOR in the first place, it is not universally true, as is supposed, and the Aristotelian doctrine requires, that hail falls not but in summer, or very hot weather. For I have myself observed it within this twelvemonth, to hail at the latter end of *November*, and that, when some frosty days have preceded, and when the coldness of the weather was complained of. Nay, the longest shower of hail, that either I, or some others, remember ourselves to have ever known, I observed to fall about a week before the end of *January*, on a night preceded by a very frosty day, which itself was preceded by a sharp fit of frosty weather. And here I must not pretermit this circumstance, that when the tedious shower was over, there came to the house, where I then was, a maid, that is servant to one of my domesticks, and related to her master, and others, how she was for a good while missed out of the beaten way, where the storm found her, by an *Ignis fatuus*, which she followed, till by its passing over a place, where she found an unpassable hedge, it both shewed her, that she was out of her way, and that it was no candle, though she had so confidently thought it one, that she called out to the party, she presumed it to be carried by. I will leave *Themistius* to unriddle, how the nocturnal air could kindle a fiery meteor by its coldness, and at the same time congeal the falling drops of water into ice by its warmth; and shall only add, that I doubt not but other observations of the like kind have been often made, though perhaps seldom recorded. For within the compass of a very few weeks of the storm, some servants of mine affirmed themselves to have observed it to hail two or three times, besides that already mentioned.

27. NEXT, if *Aristotle* have rightly assigned the cause of hail, it is somewhat strange it should not fall far more frequently in summer, and especially in hot climates, than it does, considering how often in all probability the drops of rain fall cold out of the second region into the warm air of the first. And more strange it is, that even in those parts of *Egypt*, where it rains frequently enough and plentifully (for so *Prosper Alpinus*, that lived long there, assures us it does) though not about *Grand Cairo*, yet about *Alexandria* and *Pelusium*, it should never hail no more than snow, as the same learned physician (a witness above exception) affirms. Besides, whereas it is pretended, that snow is generated in the upper region of the air, and hail always in the lower; my own observation has afforded me many instances, that seem to contradict the tradition. For I have observed in I know not how many great grains of hail, that, besides, a hard transparent icy shell, there was as it were a snowy pith of a soft and white substance, and this snowy part was most commonly in the middle of the icy, which made me call it pith, but sometimes otherwise. And lastly, whereas the favourers of Antiperistasis would have the drops of rain, in their descent, to be congealed apart in the ambient air; not to urge, how little the irregular and angular figures, we often meet with in hail, do countenance this doctrine; hail often falls in grains, too great by odds to be fit to comply with *Aristotle's* conceit. For not to mention the grains of hail I have observed my self to be of a bigness unsuitable to this opinion, divers learned eye-witnesses have informed me of their having observed much greater than those I have done: and particularly an eminent Virtuoso of unquestionable credit affirmed both to me and to an assembly of Virtuosi, that he had some years ago, at *Lyons* in *France*, observed a shower of hail, many of whose grains were as big as ordinary tennis-balls, and which did the windows and tiles a mischief answerable to that unusual bulk. And *Bartholinus* affirms, that he himself observed, in another shower of hail, grains of a more unwonted size; a single grain weighing no less than a whole pound. But though this it self is little in comparison of what I remember I have somewhere met with in learned authors, yet it may abundantly suffice to disprove the vulgar conceit about the generation of hail, till we meet in these countries with showers of rain, whose single drops prove to be of such a bigness; which I presume those, that ascribe hail to Antiperistasis, will not easily shew us.

28. I COME now to consider the last, and indeed the chiefest example, that is given of Antiperistasis; namely, the coldness of cellars, and other subterranean vaults in summer, and their heat in winter. And as the argument, wont to be drawn from hence, consists of two parts, I will examine each of them by it self.

29. AND first, as to the refreshing coldness, that subterranean places are wont to afford us in summer, I both deny, that they are then colder than in winter; and I say, that though they were, that coldness would not necessarily infer an Antiperistasis.

30. WE must consider then, that in summer our bodies having for many days, if not some weeks, or perhaps months, been constantly environed with an air, which, at that season of the year, is much hotter, than it is wont to be in winter, or in other seasons, our senses may easily impose upon us, and we may be much mistaken, by concluding upon their testimony, that the subterranean air we then find so cool, is really colder than it was in winter, or at the spring; as they that come out of hot baths think the air of the adjoining rooms very fresh and cool, which they found to be very warm, when coming out of the open air, they went through those warm rooms to the bath, and the deepness and retiredness of these subterranean caves keep the air, they harboured, from being any thing near so much affected with the changes of the season, as the outward air that is freely exposed to the sun's warming beams, which pierces with any sensible force so little away into the ground, that diggers are

not wont to observe the earth to be dried and discoloured by them beyond the depth of a very few feet. And I have found, that in very shallow mines not exceeding six or seven yards in depth, though the mouth were wide, and the descent perpendicular enough, the air was cool in the heat of summer; so that the free air and our bodies, that are always immersed in it, being much warmer in summer than at other times, and the subterranean air, by reason of its remoteness from those causes of alteration, continuing still the same, or but very little changed, it is no wonder, there should appear a difference as to sense, when our bodies pass from one of them to another.

31. AND supposing, but not yielding, that the air of cellars and vaults were really colder in summer than in winter, that is, were discovered to have a greater coldness, not only as to our sense of feeling, but as to weather-glasses; yet why should we for all that have recourse, for the solution of the difficulty, to an Antiperistasis, which it is much harder to understand, than to find out the cause of the phenomenon, which seems in short to be this; that whereas (which I shall soon have occasion to manifest) there are warm exhalations, that in all seasons are plentifully sent up by the subterranean heat, from the lower to the superficial parts of the earth, these steams, that in winter are in great part repressed, or checked in their ascent, by the cold frost or snow, that constricts the surface of the earth, and choaks up its pores; these exhalations, I say, that being detained in the ground would temper the native coldness of the earth and water, and consequently that of springs, and of the subterranean air, are by the heat, that reigns in the outward air, called out at the many pores and chinks, which that heat opens on the surface of the ground, by which means the water of deep springs and wells, and the subterranean air, being deprived of that, which is wont to allay their native or wonted coldness, are left to disclose a higher degree of it, and seem to have that quality increased, when indeed it is but freed from the mixture of its contrary, that weakened it.

32. As for the heat, we find in cellars and vaults in winter, the solutions already given will be applicable to that phenomenon also, which by this way is yet more easy to be accounted for than the other. For having first questioned the matter of fact, it will not be difficult to shew, that, though it were true, it need not be ascribed to Antiperistasis.

33. I THINK then, that it may be justly questioned, whether cellars in general are hotter in winter than they are in summer. For as for the testimony of our senses, upon which alone men are wont to conclude the affirmative, it may in this case easily and much delude us. For those places being sheltered from the winds, and kept from a free communication with the outward air, are much less exposed than others to the action of those agents, whatever they be, that produce cold in the air. So that our bodies being constantly immersed in the air refrigerated by the winter, and consequently brought nearer to the temper of that air, when we bring those bodies into cellars, the subterranean air must seem warm to us, though in itself it were unvaried as to its temper.

34. Now that many cellars are indeed colder in the midst of winter, than in the heat of summer, though not in respect of our senses, yet in respect of other bodies, that have not the same predispositions, I am induced to believe by some experiments of mine own, purposely made. And first in a frosty evening having hung out in a garden two sealed weather-glasses, that they might be reduced as near as could be to the temper of the ambient air, I brought one of them into a cellar, and it soon began manifestly to rise, and in two or three hours ascended five or six divisions, whilst the water in another sealed weather-glass, that continued suspended in the same
part

part of the garden, did rather a little subside, than at all rise, which is agreeable to the first part of what I was saying; namely, that the air, harboured in cellars, is not so powerfully affected by the ordinary efficients of cold, as the free and external air. And now as to the second part of what I was saying, that the subterranean air, though it be less affected by the outward cold, may be somewhat affected by it, instead of growing hotter by Antiperistasis; I shall add, that early in the morning in frosty weather the liquor in the same weather-glass appeared more subsided, than over night, which shews, that the external air did lessen, not increase the warmth of the air in the cellar. And having there placed a wide-mouthed glass of oil, which in thawing weather remained all night fluid as before, the same liquor, the very next night, which was a bitter frost, was so far frozen and congealed, as to sink in other oil, and keep its surface exactly, though the glass were inclined and turned upside down. And prosecuting my trial, I found, that in a sharp frost, and great snow, the liquor, that on the Thursday night was beneath the fourth knob or mark of division, a sudden thaw coming with a south wind, the next morning in the same cellar the liquor was ascended to the eighth mark. And continuing the weather-glass in the same cellar for a good while, to watch its alterations every night and morning, I remember I met with, and registered more observations, that confirmed me in my opinion, though it is so long ago, that I have forgot the particular circumstances. And after these trials meeting with a learned Polander, I did, without declaring my opinion, inquire of him, whether in his country he had at any time observed beer to freeze in cellars in frosty weather; to which he answered, that in the coldest winters, if the beer were small, the barrels would oftentimes be frozen, but not if it were strong. But I need not have recourse to foreign testimony, having myself observed here in *England*, more than one barrel of beer to be frozen in the cellar in exceeding cold weather. Inasmuch that one of the barrels being full, and the liquor expanded by freezing, was forced out at certain chinks, which seem to have been made by that expansive force, and the liquor so ejected, adhered in a considerable lump to the outside of the vessel; and yet this cellar had its windows carefully shut, and not only was near a kitchen, where fire was constantly kept, but, which was more considerable, it had this principal mark of being a good cellar, that in the heat of summer it used to afford me drink sufficiently cool. And now to requite *Eleutherius* with the testimony of that very person, physician to the Russian emperor, whose authority he alledged against me, I shall confess, that as he suspects I had conference with this doctor, and when I diligently enquired of him, whether their cellars at *Moscow* were really very cold in summer, he answered me, that they were not, and that they had distinct cellars for summer and for winter; that their small beer would quickly grow sour in their cellars in summer, if their vessels were not kept in snow; that therefore their way was to make at the bottom of their summer cellars (to which belonged a well, to receive the water dropping from the melted snow) a deep layer of snow, on which they afterwards cast a convenient quantity of water, that the whole mass might be turned into a kind of ice. In this snow they keep their casks, making sometimes a layer of snow, and a layer of cask, and digging out their vessels, as they had occasion to use them. By all which it may appear, how groundlessly it is universally affirmed of cellars, that as they seem to the sense, so they really are hotter in winter than in summer.

35. But if it should happen, (as in some places it is not impossible, but that it may) that some vaults and cellars are really warmer in summer than in winter; yet I see not, why this should reduce us to the acknowledgement of an Antiperistasis; for
neither

neither could the effect be made out by that, nor would there be any necessity to have recourse to it.

36. AND first I might content myself to repeat, what I have formerly said, to shew the incongruity of Antiperistasis in general to nature's ways of acting. And I might add, that to imagine with some late Peripateticks, (whom all their reverence to *Aristotle* has not so far blinded, as not to let them see the unreasonableness of his conceit) that in winter the warmth of the ambient air retreats into cellars and vaults to shun its contrary, is to make meer accidents, or at best inanimate agents, act with knowledge and design. But I will rather represent, that, though Antiperistasis were intelligible, it were improper to alledge it in our case. For to invigorate the warmth of the air by the cold, the air must, according to them, be environed with other cold bodies, and the heat must retire it self as far as it can from them. And accordingly it is observed, that in winter the deepest cellars are warmest; but in the case before us the subterranean air, though above, it have the cold that reigns in winter; yet beneath, the subterranean heat makes the earth very warm. This I shall not wonder, if you look upon, as new and paradoxical: and therefore I shall apply myself to the proof of it, and to convince you, I shall not imploy the observations of chymists and mineralists, for fear you should suspect them of ignorance or design; but I will use only the authority of a learned physician, who, I think, was also a professor of mathe-maticks, who, in but too many points, is a stout Peripatetick, and who, above all this, professes himself to be an eye-witness of what he relates. This author then informs us, that about the year 1615, he had a curiosity to visit the mines of *Hungary*, and particularly to go down into the deep golden mine at *Cremnitz*; and that after he had descended fourscore or a hundred fathoms, he found it excessively hot, though he had but a slight linen garment on; and though he be a maintainer of Antiperistasis, yet he affirms, that not only the overseer and workmen of that mine, but also those of divers other mines, unanimously assured him, that that lower region of the earth was all the year long very hot, and as well in winter, as he found it in summer. So that it seems, in winter the heat of the subterraneous parts less remote from the superficies, cannot be intended by the coldness of the more internal parts of the earth, those parts being themselves not always cold, but always hot.

ELEUTHERIUS. 37. But you may, *Carneades*, remember, that this very author tells you *, that he found the supreme region of the earth, as he calls it, which is that next the air, exceedingly cold, both as he went down into the mine, and as he came up again, and that he ascribes that coldness to Antiperistasis.

CARNEADES. 38. Right, but you may remember too, that he relates †, that it was in *July*, and in very hot weather, that he went down into the mine, and that, to avoid fouling his clothes, he put them off, and exchanged them for a light loose linen garment, such as the diggers wore; and this himself mentions, as that which much increased the coldness he felt. So that, if, besides this, we consider, that he descended into a cooler place, with a body already affected with the great heat which he elsewhere takes notice, that that season had given the outward air, and perhaps much heated by riding or walking to the mine, we shall not wonder, that he found the change very sensible as he went down. And we shall less wonder, that he found the upper region of the earth, as he calls it, more cold, when he came up again; since, besides the toil of going to and fro, and ascending through narrow, low, and difficult

* — *Cæsimus in hanc fodinam per gradus valde strictos profundè admodum descendere, per regionem certè frigidissimam, quam solis vestibus metallicis opertus, multo frigidiorè sensì, &c. p. m. 130.*

† — *In quam descendì mense Julio, quo anni tempestas vigeat calidissima, siccissimaque. p. m. 130.*

passages, he came out of a place excessively hot; insomuch that he tells us, that the overseer of the mine would not go back with him the same way he came, but took a far shorter, though it were a more dangerous way, causing himself to be drawn up in a perpendicular groove; and rendering this reason, that it was very unhealthy, when one comes out of a place, where the diggers work naked, and where one is even melting into sweat, to make any long stay in the superiour region of the earth. So that besides that this author, altho' he maintains Antiperistasis, yet he allows this upper region to be hot in winter, as well as cold in summer; and consequently, that in winter it has not a cold region beneath, as well as above it; which is enough to vindicate the thing, for which I first alledged his testimony: Besides this, I say, to me, who, though I willingly thank him for his narrative, am much more swayed by what he relates, than by what he thinks; the matter of fact seems very favourable to my opinion: for you see, that I can justly refer the cold he felt near the surface of the earth, to the deception of his sense, but the heat he felt within the bowels of the earth cannot be referred to the same cause; since he tells us, that at the top of that great and perpendicular groove, by which the mine-master was drawn up, there ascended a plentiful smoke, that was, even above the mouth of it, felt actually hot: and, besides his own confession, that the deep parts of the mine were more than seemingly hot, I can draw further proofs from these two circumstances, that I have elsewhere met with, in his narrative; the one, that on the surface of the earth, it was then excessively hot; another, that the * smoke, which, notwithstanding this heat, appeared hot, had in its ascent passed through four or five hundred foot of a cold region of the earth, whereby it may well be supposed, to have been much infrigidated. To these relations of the learned *Morinus*, I will add, that the archbishop of *Upsal* affirms †, that in the year 1528, being in *Poland*, he went to visit those deep mountains (as he terms them) whence they dig solid salt, and having descended fifty ladders, found, in the deeper places, that the workmen were naked, because of the heat. So that supposing the time of the year not to be considerable in this case, it seems by this relation, that, provided a man descends low enough into the bowels of the earth, he will find it very hot, even in places that want those metals, or marchasites, or other like mineral substances, by the action of saline liquors, or exhalations, upon which you, *Eleutherius*, have, I remember, sometimes suspected, that the heat observed in mines may be produced.

39. I HAVE hitherto shewn, that the heat of cellars and vaults in winter has been very improperly, and now I come to shew, that it has been as unnecessarily ascribed to Antiperistasis. For as the air of those places is protected from the greatest part of the adventitious coldness, that reigns in the outward air, so the subterranean air has a positive cause of heat in winter, that it has not in summer. For, as I formerly took notice, in summer the pores of the earth, being dilated and opened by heat, the warm exhalations, that were wont to be mingled with moist vapours in the bowels of the earth, are called out, and exhaled away. For as in the winter, the surface of the earth being hardened by frost, or the pores of it choaked up, or at least much obstructed, the hot steams, that, as I lately proved by our French author's testimony (to which I could add that of eminent chymists and mineralists) do continually, and

* *Exhalatio aëre levior per ipsum puteum ascendit magno impetu, in ejus summitate adhuc sensibilibus calida ipsa aestate, licet supremam terræ regionem tunc frigidissimam permeat.* Pag. 128. See also page 125.

† *In Polonia vero montes profundissimi salis sunt, præsertim in Vielica & Bochna, ubi videndi causâ transcensu scalis, vidi in profundioribus locis laboratores nudos ob calorem, ferreis instrumentis eruere opulentissimum thesaurum salis, veluti aurum & argenti ex mineris inexhaustis.* Olaus Mag. lib. 13. p. 382.

copiously enough ascend from the warm region, or lower parts of the earth, are in great part detained and imprisoned in cellars, and other subterranean cavities, where consequently they produce such a heat, as to those, that come out of the cold air, may be very sensible. And the rather, because whilst men, by the coldness of the season, are more than ordinarily careful, to stop up the passages, at which the external air may get in, they do, though designlessly, stop up the vents, at which the subterraneous exhalations might get out. And to shew you, that this last circumstance is not impertinently taken notice of, I shall tell you, that a very grave author having occasion to mention cellars, relates it, as a practice in divers houses of a town, where he had been, to keep vents in their deep cellars, which in the summer were from time to time opened, partly to keep the places sweet and wholesome, and partly to let out the warm exhalations, that would else hinder their liquors from keeping so fresh, and well. And these steams were affirmed to have been several times taken notice of, to ascend visibly into the free air like a smoke; which several phenomena, and particularly what I formerly related of the hot fumes, that manifestly ascended out of the great groove in the Hungarian mine, may keep us from thinking incredible.

40. AND now, by what I have hitherto discoursed, I have made way for the solution of a phenomenon, that is wont to be much urged in favour of Antiperistasis; namely, the smoaking of water, that is drawn in frosty weather out of deep wells and springs.

41. BUT, first, I must advertise you, that it is improperly enough, that some urge for Antiperistasis such examples, as the strange spring near the temple of *Jupiter Ammon*, which *Lucretius* and others have observed to have been exceeding cold in the day-time, and as hot at night: for, not now to examine, whether this story be not fabulous, or might not be ascribed to some crafty trick of the idolatrous priests, that had a mind to impose upon *Alexander*, as well as others, and procure an admiration to the place; I consider, that this, and other the like cases, such as are the springs mentioned in the islands of *Maldivia*, by *Pyrard* (a French author, that was shipwrecked, and lived long in those parts) must be referred to the peculiar nature of the springs, or some other hidden cause: since, if the water of them were but ordinary, and the phenomena were the effects of Antiperistasis, it might justly be expected, that the like should happen in all springs, or at least in very many, which, that it does not, common experience shews us. And I would say, that this might be the case of the spring, you mention out of Captain *James's* voyage, (pag. 63.) but that besides, that he does not say expressly, that it was frozen in *July*, but only, that then it afforded him no water, which might happen upon divers other accounts: and besides, that it is manifest, that in far hotter countries, where the excessive heat of the air might more intend the subterranean cold, if Antiperistasis could do it, there is no talk of any such degree of cold in summer, as to freeze the springs; besides this, I say, there seems to be, through some mistake or other, a contradiction in the relation itself, since in the same voyage, speaking of the same month of *December*, he expressly says, that their well was then frozen up; so, (pag. 58.) *that dig as deep as they could, they could come by no water*. And he complains, on that occasion, of the unwholesomeness of melted snow-water. It is true, that he soon after mentions a spring, that he found under a hill's side, which did not so freeze, (pag. 59.) but that he could break the ice and come to it: but by his very sending far from his house to the spring, it appears to have been a consequence, and therefore a proof, of the uselessness of his well in *December*; as his affirmation, that it continued all the year so, as to be serviceable, when the ice was broken, shews, that the Antiperistasis did not freeze it

up in summer. And having cleared myself of such a testimony of this ingenious navigator, as would appear very illustrious, if there had been no mistake about it, I shall not scruple to add, that the late publisher of the Latin description of *Denmark* and *Norway* informs us, that in or near that little Danish island *Hueena*, wherein the famous *Tycho* built his *Urani-Burgum*, there is one spring among many ordinary ones, that even in the coldest winter is never frozen; which, subjoins my author, does in these regions exceeding rarely happen to be found. *Olaus Magnus* * also relates, that in another part of the King of *Denmark's* dominions, namely near *Nidrosia*, one of the chief cities of *Norway*, there is a lake, that even in that northern region never freezes. And the learned *Josephus Acosta* mentions †, that among a very great number of hot springs to be met with in *Peru*, *At the baths, which they call the baths of Ingua, there is a course of water, which comes forth all hot and boiling; and joining unto it there is another, whose water is as cold as ice.* He adds, *That the Ingua (or the Peruvian emperor) was accustomed to temper the one with the other, and that it is a wonderful thing to see springs of so contrary qualities, so near one to another.* These relations, as I was saying, I scruple not to mention, though at first sight they may seem to disavour my cause. For by these and some others it may appear, that springs may obtain very peculiar and strange qualities, from the nature of the places whence they come, or through which they pass, or from some other causes, that are as hidden from us, as the originals of these rare waters. And this being once proved, who knows what interest such causes, as we are strangers to, may have in some phenomena, that are wont to be wholly ascribed to the heat and cold of the superficial part of the ground, and what influence they have upon many other springs (besides those above-mentioned) some of which, that are very deep, may rise from the warm region of the earth, where they may be affected by the place, as both these and others may be by mineral juices and steams, (such, perhaps, as we know nothing of) though we well know, that some of them, that are saline, without being at all sensibly hot, will powerfully resist congelation.

42. But having hinted thus much on this occasion, I shall now proceed to consider the smoking of waters drawn from deep places in frosty weather; and shew, that it does not necessarily conclude such water to be warmer in winter, since that effect may proceed not from the greater warmth of the water in such weather, but from the greater coldness of the air. For we may take notice, that a man's breath in summer, or in mild winter weather, becomes very visible, the cold ambient air nimbly condensing the fuliginous steams, which are discharged by the lungs, and which in warmer weather are readily diffused in imperceptible particles through the air. And I have observed, upon the opening of issues in some men's arms, that though no smoke be visible in summer, it will be very conspicuous in exceeding sharp weather; though men's arms, at least the external parts of them, seem to have less heat in frosty weather, than in summer; since in the former of those seasons, they are wont to be manifestly more slender, the fleshy parts and juices being condensed by the coldness of the air. And though the insensible transpirations, that continually exhale from all the parts of our bodies, are not wont to be visible here, even in winter; yet in extremely cold countries, as *Nova Zembla*, or *Charleton Island*, those effluvia have been observed, not only to be thickened, but to be turned into ice itself, sometimes within the seamen's shoes. And here in *England*, having not long since employed a

* *Hancque naturam, lacum similem, prope metropolin Nidrosensem regni Norvegiæ, habere compertum est, et præcipue argumento, quod in mediis frigoribus nunquam congelatur.* Lib. 2.

† *Joseph. Acost. Hist. Ind. pag. 174.*

labouring man to dig a deep hole in very frosty weather, two servants of mine; that stood by to see him work, did both of them assure me, when they returned, that the steams of his heated body were frozen upon the outside of his waistcoat, which, one of them, whilst the other was about to give me notice of it, inconsiderately wiped off.

43. AND since we see, how fast the water in ponds and ditches waistes and decreases in summer, there is no cause to doubt, but that it does then continually emit exhalations, as well, if not much more plentifully, than in winter: which may be manifestly confirmed by this, that in the summer one shall often see, in the mornings or evenings, the face of the water covered with a mist or smoke, that rises out of it. And I have sometimes taken pleasure to see this aggregate of exhalations hover over the water, and make, as it were, another river of a lighter liquor, that conformed itself, for a considerable way, to the breadth and windings of the stream, whence it proceeded. And I think it will be easily granted, that the water in summer-time is at least as warm at noon, when such exhalations are not visible, as in the morning when they are, though the air be colder at this part of the day, than at that; which observation gives us the true reason of the phenomenon.

44. AND though, notwithstanding all this, it were made to appear, that in some cases, the smoking water of springs may be really warmer in winter than in summer; yet a sufficient reason of the phenomenon may be fetched from what I have already delivered about the detention of the warm subterranean vapours by the frost, and snow, and rain, that make the earth less perspirable in winter.

45. AND because I know *Themistius* will look upon a thing so disagreeable to the vulgar opinion, of the coldness of the whole element of earth, as a paradox; I will take this opportunity to add a further confirmation to what I have been saying.

46. AND first, that there arise copious and warm steams from the lower parts of the earth, may be proved, not only by what I have already mentioned, touching the Hungarian mines, but by the common complaint of diggers in most, though not in all deep mines, that they are oftentimes troubled, and sometimes endangered by sudden damps, which do frequently so stuff up and thicken the subterranean air, that they make it not only unfit for respiration, but able to extinguish the lamps and candles, that the miners use, to give them light to work by. And I remember, that I have visited mines, where having enquired of the diggers, whether those hot exhalations, that compose their damps, did not sometimes actually take fire within the bowels of the earth? I was answered, that in some of their pits (and particularly in one, that they shewed me) though not in all, they did; insomuch that the exhalation suddenly kindling, would make a report at the mouth of the pit like a musquet, or a small piece of ordnance, and the flame would actually burn off the hair, and scorch the skins of those workmen, that did not seasonably get out of the pit, when the exhalation appeared to be near in ascension, or did not nimbly fall down flat with their faces to the ground, till the flame was gone out. And one of these workmen, that I asked, affirmed himself to have been several times, to his no small trouble, so burned, and that (if I much misremember not) twice in one day. And it seems to me as well as to *Morinus* very probable, that those great quantities of rain and snow, and storms, and (perhaps) some other meteors, that are taken notice of in winter, may rather consist of these subterranean steams, than the vapours and exhalations attracted by the sun, (or at least may as much consist of the former, as the latter.) For his heat is then very languid, and acts upon the ground but during the day-time
which

which is very short, (whereas those meteors are generated indifferently at all hours of the day and night) and the sky is oftentimes, for many days together, quite overcast with clouds, and the surface of the ground so conſtituted with froſt, that it will ſometimes freeze even in the ſun-ſhine: ſo that it is not near ſo likely, that the heat of the ſun, in the miſt of all theſe diſadvantages, ſhould be able to elevate ſo great a plenty of exhalations and vapours, as are requiſite to compoſe the rain, and ſnow, and ſtorms, that ſometimes laſt almoſt all the winter, as that they ſhould be ſupplied by ſubterranean ſteam copiouſly ſent up from the heat, that continually reigns in the lower parts of the earth, and by tra- verſing the ſea, and at other vents, get up into the air.

47. To make out this, my formerly quoted French author (*P. m.* 136.) relates a very memorable thing, that was told him by the maſters of thoſe mines in *Hungary*, (which are at leaſt as deep as any that I remember I have ſeen or read of) namely, that the miners were able certainly to foretel ſooner than any other mortals, the tempeſts and ſudden mutations, that were to happen in the air. For when they perceived by the burning blue of their lights, and by other manifeſt ſigns, that they could eaſily take notice of in their grooves, that ſtore of the tempeſtuous damp (if I may ſo call it) was aſcending from the lower parts of the earth, though the ſky above were clear, and the air calm; yet they could aſſuredly foretel the approach of a ſtorm, or ſome other great alteration in the air, which would accordingly enſue within no very long time after. And to confirm this narrative, I ſhall add, not only that it is agreeable to what I lately told you was affirmed to me by other mine-men, but that having enquired of a very ingenious phyſician, who lived many years in *Cornwall*, (a country you know famous for tin-mines, ſome of which are infamous for the damps that infeſt them) he told me, that divers of the experienced fiſhermen aſſured him, that oftentimes they did perceive fiſhes ſhining in the night, ſometimes in one place, ſometimes in another, which was ſuppoſed to be kindled by the ſulphureous and other ſubterraneous exhalations; and that, when they perceived thoſe fires (eſpecially if any number appeared in ſeveral places) thoſe, that were well acquainted with the coaſt, would not continue long out at ſea, but rather quit an opportunity of catching fiſh, than not make ſeaſonably to the ſhore; having often obſerved, and particularly this laſt year, that bold and unexperienced mariners, by ſlighting theſe fore-runners of ſtorms, were in few hours ſhipwrecked by them.

48. To this I ſhall add, what happened ſome years ſince, upon the *Iriſh* coaſt, near a ſtrong fortrefs, called *Duncannon*, where divers of the ſhips royal of *England* lying at anchor, in a place where they apprehended no danger from the wind, there ſeemed ſuddenly to aſcend out of the water, not far from them, a black cloud, in ſhape and bigneſs not much unlike a barrel; which mounting upwards, was not long after followed, as the moſt experienced pilot foretold, with ſo hideous a ſtorm, as forced thoſe ſhips to go to ſea again, and had like to have caſt them away in it. And this account was both written by the principal officers of the ſquadron to their ſuperiours in *England*, and given, ſoon after it happened, by the chief of thoſe eye-witneſſes (and particularly by the pilot) to a very near kinſman of mine (well verſed in maritime affairs) that commanded the land-forces in thoſe parts, as a truth no leſs known than memorable.

49. AND on occaſion of what I was ſaying, about the eruption of hot ſteam, in ſeveral parts of the earth, I now call to mind ſomething, that I have met with in a very ſmall, but curious diſſertation, *De admirandis Hungariæ aquis*; whoſe anonymous author I gather, from ſome paſſages in the tract itſelf, to have been a nobleman, governour of *Saros*, and ſome other places in *Hungary*, and to have written this diſcourſe,

discourse, both for, and to that inquisitive German Baron, *Sigismundus Liber*, famous for the account he gave the world of the embassy, whereon he was sent by the German to the Russian emperor. This anonymous, but noble writer, tells us then, that in that part of *Hungary*, which he calls * *Comitatus Zolienfis*, there is a gaping piece of ground, which does emit such mortal expirations, that they suffocate, not only cats and dogs, purposely held at the end of long poles over the cleft, but kill even birds, that attempt to fly over it. And in other places of the same tract, I have met with many other relations, which if I had time to make a particular mention of, would much countenance what I have been lately saying: but though I premit several other instances, I cannot but take especial notice of one, which (together with what I lately mentioned to have happened near *Duncannon*) may make it probable, that not only under the surface of the dry ground, but in that part of the terrestrial globe, that is covered with water, there may arise steams, (and consequently exhalations) actually, and that considerably hot. For in one † place he takes notice, that, not far from the well-known city of *Buda*, there is a hot spring (which they call *Purgatory*) which the waters of *Danubius* itself are not able to keep from being hot: nay, within the very banks, betwixt which that great river runs, there boil up hot springs, where those, that will go deep enough into the water, may commodiously bathe themselves. And ‡ elsewhere speaking of the river *Istroganum*, in the same country, he adds, that not only the banks of it, but within the very river itself, one may discover hot springs, by removing the sand at the bottom with one's feet. To this I shall add, that having heard of a ditch in the North of *England* (in some regards more strange, though less famous than the sulphureous grotto near *Naples*) whence not only subterranean steams, but those so sulphureous, as to be easily inflammable, did constantly and plentifully ascend into the air, I had the curiosity to make enquiry about it, of the minister of the place, (a very learned man, and conversant in mines) who then happened to be my neighbour, and he attested the truth of the relation upon his own knowledge. And it was confirmed to me by a very ingenious gentleman, who went purposely to visit this place, and found it true, that a lighted candle, or some such actual burning body being held, where this exhalation issued out of the earth, would kindle it, and make it actually flame for a good while, and (if I misremember not) as long as one pleased. And as this place was but a few years since taken notice of, so there may be probably very many others, yet undiscovered, that may supply the air with store of mineral exhalations, proper to generate fiery meteors and winds. I remember, that having lately asked an inquisitive gentleman, that is a great searcher after mines, whether he did not observe some meteors near those places, where he is most conversant? he told me, that it is very usual in some of them, to see certain

* Qui vero in comitatem Zolensem, dum aquas persequimur, ventum est, non possum præterire biatum terræ iisdem in locis famosum ob pestilentes expirationes, quibus aves supervolantes, & quævis alia animalia extinguuntur constat, manifesto eorum experimento, qui, &c. Pag. 74.

† Ibidem est sub dio fons calidarum cæteris amplior, quem Purgatorium vocavere, ea nimirum ratione, quod, quemadmodum proditum est in purgatorio pœnas nocentium pro noxarum modo, alias acerbiores, alias mitiores, ita quædam insunt aquæ hoc in fonte discrimina, nam quæ in eum à Danubii ripâ aditus est, subfrigida primum, mox tepida, & quo in eum penetraris altius hoc magis calet. In recessu vero interiore tam est calida, ut ferri non possit. Est etiam is calor haud dubie aquæ hujus proprius; nam alia, quæ dixi, temperamenta verisimile est à Danubio accedere, qui crepidinem hujus fontis lambit, & cum vel modicè excrevit, totum inundat, neque tamen ita restinguit, quin caleat. Quin intra ipsam ripam, qua Danubio perennis cursus est calidæ ebulliant, ubi qui altius mergi volunt lavare consueverunt. Pag. 57.

‡ Neque in ripâ tantum eruntur Calidæ, sed etiam intra amnem, si fundum ejus pedibus suffodias. Calet aut immodicè, nec sunt idoneæ balneis, nisi temperentur, quod admixtione frigida de proximo hauriæ in proclui est. Pag. 65.

great fires moving in the air, which in those places, diggers, because of some resemblance (real or imaginary) are wont to call dragons. [And the Russian emperor's physician, you were speaking of, informed me a while since, that he had, not long ago, observed in winter a river in *Muscovy*, where, though the rest of the surface was frozen, there was a part of it near a mile long, that remained uncovered with ice, which probably was kept from being generated there by those subterraneous exhalations, since he says he saw then ascend up all the way like the smoke of an oven.] And in case the matter of fact delivered by *Olaus Magnus* * be true, concerning the strange thaws, that sometimes happen, with terrible noises in the great lake *Veter*, those wonderful phænomena may not improbably be ascribed to the ascent of great store of hot subterranean steams, which suddenly cracking thick and solid ice in many places at once, produce the hideous noises, and the hasty thaw, that he speaks of. And this suspicion may be countenanced partly by this circumstance, that before these sudden thaws, the lake begins with great noise to boil at the bottom; and partly by what is related by a more authentick writer, I mean that learned traveller the Jesuit *Martinius*, who witnesseth, that at *Peking*, the royal city of *China*, it is very usual, that after the rivers and ponds have continued hard frozen over, during the winter, the thaw is made in one day; which, since the freezing of the waters (as he tells us) required many, makes it very probable, that the sudden thaw is effected (as he also inclines to think) by subterranean steams, which I may well suppose to be exceeding copious, and to diffuse themselves every way to a very great extent, since they are able so soon to thaw the rivers and ponds of a large territory, and that (which makes mainly for my present purpose) beginning contrary to vulgar thaws, from the bottom upwards.

50. AND having thus manifested, that the lower parts of the earth do send up great store of exhalations and vapours to the upper parts, it will be obvious to conceive, that as in divers places of the terrestrial globe, these steams get into the air, either by the advantage of finding vents, such as those I have already mentioned, or by growing copious enough to force themselves a passage; so in most other places, where the ascending steams find no commodious vents, or are too faintly driven up to gain themselves a passage, they must be repressed or detained beneath the surface of the earth, which has its pores in winter usually choaked up with snow or rain, or its surface constipated and hardened with ice or frost: so, that these exhalations being pent up, and receiving fresh supplies, from time to time, from beneath, it were no wonder, if they should somewhat warm deep cellars and wells, where they are thus detained; and therefore our husbandmen do not speak altogether so improperly, when they say, that the snow keeps the ground warm. And I remember, that *Dr. Smith*, the learned English Ambassador into *Moscow*, makes it to be one of the principal reasons of the great fertility, he justly ascribes to the country thereabout, that during almost all the winter, the ground is to a great height covered with snow; which does not only enrich it by the fertilizing salt, which the earth gains from the snow, when that comes to be melted, but does also contribute to its improvement, by choaking up, or obstructing the pores, at which the nitro-sulphureous, and other useful corpuscles, that are sent up by the subterranean heat, would easily get away. And lest, Gentlemen, you

* *Nec prætereundum hic puto Lacum esse LX. milliarum in longitudine, & XX. in latitudine Italicorum, Veter appellatum, in Regno Ostrogothorum, quæ talis est naturæ, quod cum tempestuoso vento congelatus fuerit, & tempus resolutionis imminet, vehementissimo strepitu incipit fundo ebullire & commoveri, magna violentia percurrere in parvas rimas, vel scissuras, quæ sunt in glacie, & has in modico temporis spatio faciens valde latas, licet pro tunc glacies in spissitudine habuerit, plusquam unum, vel duo brachia. Lib. primo, pag. 23.*

should think, that it is only by the ratiocination, that I conclude, that there is really great store of warm steams detained under ground in the winter; I shall add this sensible observation, received from the Russian emperor's physician already often mentioned, by whom I have been assured, that about *Muscovy*, where the surface of the ground is far more constricted in winter, than it is in these parts, and where they are wont to keep their cellars much closer, the subterraneous exhalations being hindered to fly abroad, will in time multiply so fast, that he assures me, that upon the unwary opening of the doors of cellars, that have been long kept shut, there would fall out a warm smoke, and very thick, almost like that of a furnace, and sometimes the steam, that issues out, will be so gross and plentiful, that it has brought men into danger of being suffocated by it.

51. AND now, gentlemen, having shewn, that though experience be so confidently appealed to by the maintainers of Antiperistasis, yet she has not hitherto afforded them any thing, that much favours their cause; it remains, that I shew, that she bears witness against it. For besides that some passages of my late discourses do really contain phenomena, that not only do not favour Antiperistasis, but may justly be employed as experiments against it, I shall *ex abundanti* (as they speak) present you with something, which I necessitated experience to supply me with, that seems expressly to overthrow it.

52. I MIGHT urge against those, who, though they begin to be ashamed of the doctrine of the schools, would establish an Antiperistasis upon the account of what they call a *fuga contrarii*, that the very instance they are wont to bring for their opinion, may be retorted upon them. For when they tell us, that in winter, the heat, to fly the cold of the external air, retires itself into the lower parts of the earth, and there harbours in cellars and wells, as may be proved by the smoking of water drawn from deep wells, which argues its heat, the vapours, which fly away, being, as vapours hot in comparison of the outward air; we may easily answer, by demanding, why, if the heat, that was harboured in a smoking bucket of water, have the wit or instinct to fly from its contrary, it does not in the bucket, as it is said to do in the well, retire itself as far as it can from the surrounding cold of the ambient air; but instead of retiring to the innermost parts of the water (those being remotest from that) it needlessly flies abroad, with the vapours it excites, and does, as it were, of its own accord cast it self into the arms of the enemies it should shun. And indeed what I just now mentioned to you, as related to me by Dr. *Sam. Collins*, the great duke of *Muscovy's* physician, does sufficiently manifest, that the cause, why the corpuscles, that keep cellars warm, abide beneath the surface of the earth in winter, is not that they fly the cold as their enemy, but that they are pent up beneath the ground; since, when vent is given them, they immediately rush into the open air, without fearing the cold even of *Russia* in the very midst of winter.

53. BUT I shall press this no further, but rather add, that the doctrine of Antiperistasis is as little beholden to the following experiment, which I sometimes tried, in order to the disabusing some abettors of *Themistius*. I took then an iron-rod, of about the bigness of a man's finger, having at one end of it a very broad and thick piece of iron (shaped almost like a spatule) that the quantity of the matter might, upon the ignition of the iron, make the heat very considerable: then having caused this thick end to be made red-hot in the fire, and having suddenly quenched it in cold water, I could not perceive, that the other end of the rod, by which it was wont to be held, did at all grow sensibly hot, as a favourer of Antiperistasis would have expected it should do to a very high degree, as presuming, that the innumerable particles of heat, that swarmed in the compact body of the red-hot part of the iron, must, to fly the

cold of the water, retire in throngs towards the other extreme of the iron, and make it exceedingly hot. And lest any pre-existent warmth should hinder me from perceiving an increase of heat, in case any were produced in the handle of the iron, I caused it the next time the trial was made, to be kept in cold water; and yet even then, the immersion of the broad and candent end into the cold water brought as little of sensible heat to the other end, that I held in my hand, as it had done the time before; and having caused the experiment to be tried by another, the account I received was, that it succeeded with him, as it had done with me.

54. BUT this is not the main thing, gentlemen, that I intend to acquaint you with, there being an expedient, that I purposely devised to make one experiment, more considerable against Antiperistasis, than are in several mistaken observations of the Peripateticks to establish it.

55. I took then a good sealed weather-glass, twelve or fourteen inches long, furnished with good spirit of wine, and having provided an open-mouthed glass of a convenient shape and size, and filled it but to a due height (that it might not afterwards run over) with common water, I so ordered the matter, that the stem of the thermoscope being supported by the cork, into which by a perforation or slit it was inserted, when the glass was stopped by the cork, the whole ball of the thermometer was immersed in the water, that filled the wide-mouthed glass, and did no where touch either the bottom or the sides of the glass, so that the ball or bubble was every way surrounded with water. The instrument being thus prepared, we observed at what station the ambient cold water had made the tinted spirit rest in the stem of the thermoscope; and then having provided a fit proportion of warm water in a commodiously shaped vessel, I removed the instrument into it, and placed it so, as that the external warm water reached to a convenient height on the outside of the open-mouthed glass: but though I carefully watched, whether the heat of the external water would increase or strike inwards the cold of that water, which did immediately encompass the ball of the weather-glass; yet I perceived no such matter, the tinted spirit in the stem keeping its station (without sinking beneath it) till the heat, after a while, having by degrees been diffused through the formerly cold water, by the intervention of that now warmed, the tinted spirits in the thermometer began to ascend.

56. AND to reduce the other part too of the doctrine of Antiperistasis, to the determination of an experiment, the same thermoscope was placed in the same wide-mouthed glass just after the former manner; only instead of the cold water, that, which immediately surrounded the glass, was warm; and when the warmth had impelled up the tinted spirit, till its ascent began to be very slow, I immersed the instrument to a convenient depth in a vessel, that contained highly refrigerated water, mingled with divers pieces of ice. But notwithstanding my watchfulness, it did not appear to me, that the water, that did immediately encompass the ball of the weather-glass, was at all increased or intended, by that liquor's being besieged by water exceeding cold; for the languid motion of the tinted spirit upwards was not hereby so much as sensibly accelerated, (as it must have been considerably, if the heat of the internal water had been so augmented, or struck inwards by the cold of the external, as the schools doctrine would have made one expect) but rather the ascent was, by the chillingness of the contiguous water, quickly checked, and the formerly ascending spirit was soon brought to subside again. And to give myself the fuller satisfaction about some of the chief phenomena of this, and the former experiment, I had the curiosity to observe them more than once.

P O S T S C R I P T.

A sceptical Consideration of the heat of cellars in winter, and their coldness in summer.

THE foregoing discourses of *Carneades* seem to have sufficiently shaken the foundations of the vulgar doctrine of Antiperistasis, so far forth as it is superfructed upon the vulgar observations and phenomena, whereon men are wont to build it; and it seems to have made it also highly probable, that in case some of the examples wont to be produced in favour of Antiperistasis should prove historically true, yet those phenomena may, more congruously to the wonted proceedings of nature, be explicated by the detention of calorifick or frigorifick corpuscles, by the operation of the external cold or heat, than to a certain inexplicable self-invigoration, which is commonly proposed in such a way, as invests inanimate bodies with the prerogatives of free agents. But though *Carneades* his adversaries seem not to have well made out the historical part of the received doctrine concerning cold; yet upon an impartial survey of what has been alledged on both sides, I freely confess, that to me some of the matters of fact themselves seem not yet so clearly determined as I could wish: for as to the obvious phenomena, that nature does, as it were, of her own accord present us, they seem to have been but perfunctorily considered, and our senses only being the judges of them, we may easily, as *Carneades* argues, be imposed upon by the unheeded predispositions of our organs. And as for contrived and artificial experiments, there scarce seem to have been any made fit to clear the difficulties, that invite me to suspend my judgment, as to the grand question (or fact) whether cellars, and other subterraneous places, be really hotter in winter than in summer.

It is true, that I have scarce met with any point, wherein the modern schoolmen seem to have so much consulted nature, as in this of Antiperistasis. For enquiring what has been written of that subject, that may either confirm or oppose what has in the precedent dialogue been delivered about Antiperistasis; I found, that the curiousness and importance of the subject have made two or three of those writers less negligent than I suspected. But though I have lately met with in them an experiment or two, that seem cogently to evince, I do not say an Antiperistasis in the sense of the schools, but that subterranean places are really hotter in winter than in summer, yet I must for a while longer continue my suspension of judgment, which that even such persons, as are circumspect themselves, may not think unreasonable, I will briefly subjoin the grounds of my scepticism about this matter.

FIRST then, the learned Jesuit *Zucchi*, who is wont to be far more industrious than other Aristotelians (and on some subjects is careful to propose experiments, though he be not so clear and happy in expressing his thoughts) assures us somewhere, that having kept a good sealed weather-glass, for three years together, in a good cellar, he found the water to rise by the coldness of the ambient air in the summer, and to be depressed by the rarefaction of it in the winter; which seems undeniably to infer, that whatever be the reason of it, the heat in subterranean places is indeed greater in winter than in summer. And another recent schoolman, who, as I am told, is of the same order, though the learned man published his little book under one of his disciple's names, affirms, that he found by a weather-glass, that a well at the place, where he lived, was colder in summer, and hotter in winter. And these

assertions of *Zucchi*, and the other Jesuit, do, I confess, restrain me for a while from yielding a full assent to what *Carneades* hath delivered, as to the matter of subterranean cold and heat. But on the other side, I am not hitherto reduced by these experiments, to declare with his adversaries against him, because of the following scruples.

FIRST then I consider, that it is not universally true, which is wont to be indefinitely affirmed, and believed, that cellars and other subterranean places are hotter in winter than in summer. For the instances produced by *Carneades* seem plainly enough to manifest the contrary, and my own observations made in a cellar with a sealed weather-glass do keep me from dissenting from *Carneades* as to that point. I would therefore make a distinction of subterranean places; for some are deep, as the best sort of cellars; others deeper yet, as the Hungarian mines, mentioned by *Carneades* out of *Morinus*; and some again are but shallow, as many ordinary cellars and vaults: of these three sorts of subterranean places, the deepest of all do not, as far as the authority of mineralists above alledged may be relied on (for I am yet inquiring further) grow hot and cold according to the several seasons of the year, as the vulgar doctrine of Antiperistasis requires, but are continually hot: the shallower sort of subterranean places, though by reason of their being fenced from the outward air, they are not so subject to the alterations of it, whether to heat or cold, as open places are; yet by reason of their vicinity to the surface of the earth, they are so far affected with the mutations, which the outward air is liable to in several seasons of the year, that in winter, though they be warm in respect of the colder air abroad, yet they are really (at least some of them) as far as I have tried, colder in very cold weather, and less cold in warm weather. And in this opinion I am confirmed by two things; the one, that having purposely inquired of the *Polonian* nobleman mentioned by *Carneades*, whether he had observed in his country, in sharp winters small beer would freeze in cellars, that were not very deep, but would continue fluid in those that were, he assured me he had taken notice of it: The other thing is the confession of the anonymous Jesuit lately mentioned, who acknowledges, that he found but little difference between the temperature of the water in the well he examined in summer and in winter, though it were a considerably deep one; and adds a while after, that at *Florence*, where the subterranean vaults are shallower, the air is observed to be colder in winter than in summer, though at *Rome*, in their deep cellars, the contrary has been found. So that the lowermost sort of subterranean cavities being, for aught appears, perpetually hot, and the upper or shallower sort of them being colder, not hotter in cold weather than it is in warm, it is about the temperature of the middle sorts of them, such as are the deeper and better cellars, that the question remains to be determined. And thus much of my first consideration.

THE next thing I shall offer to be considered is this; that it is not so easy a matter, as even philosophers and mathematicians may think it, to make with the weather-glasses hitherto in use, an experiment to our present purpose, that shall not be liable to some exception, especially if the cellars or wells, where the observations are to be made, be very deep. For the gravity of that thick and vapid subterranean air, and the greater pressure, which the air may there have, by reason of its pressing, according to an atmospherical pillar lengthened by the depth of the cellar or well, may, in very deep cavities, as well alter the height of the water in common weather-glasses, as heat and cold do, and so make it uncertain, when the mutation is to be ascribed to the one, and when to the other; or at least very difficult to determine distinctly, what share is due to the pressure, and what to the temperature of the air. And this uncertainty may be much increased by this more important consideration, that not only

only in places, where the heights of the atmospherical cylinders are differing; the pressures of the air upon the stagnant water in the weather-glasses may be so too, but even in the self-same place, the instrument remaining unmoved, the pressure of the atmosphere may, as I have often observed, hastily and considerably alter, and that without any constant and manifest cause (at least that I could hitherto discover) so that the erroneous estimate, that may be hereby suggested of the temperature of the air, can scarce possibly be avoided, without the help of a sealed weather-glass, where the included liquor is subject to be wrought upon by the heat and cold, not pressure of the air. So that to apply this to *Zucchi*'s experiment, unless he had been aware of this, and unless I knew, that he had divers times made his observations, with the assistance of a sealed weather-glass, it may be suspected, that he might accidentally find the water in his common weather-glass (for such a one it appears he used, as probably knowing no other) to be higher, when he looked on it in summer, than when he looked on it in winter, not because really the subterranean air was colder in the former season, than in the latter, but because the atmosphere chanced then to be heavier. And when I remember, in how few hours I have sometimes, and that not long since, observed the quicksilver, both in a good barometer, and even in an unsealed weather-glass furnished with quicksilver, to rise almost an inch perpendicularly, without any manifest cause proceeding from cold; I cannot think it impossible, that in long weather-glasses furnished only with water, or some such liquor, the undiscerned alterations of the atmosphere's pressure, may produce very notable ones in the height of the water in such instruments. But this is not all, that a jealous man might suspect. For *Zucchi* having, for aught appears, made his observations but in one place, we are not sure, but that that may be one of those, whereof there may be many, on which subterranean exhalations have a peculiar, and not languid influence; as *Carneades* has towards the close of his discourse made probable, out of the relations of *Olaus Magnus*, and *Martinius*, touching the great and sudden thaws, that sometimes begin from the bottom, and thereby argue their being produced by copious steams, that ascend from the lower parts of the terrestrial globe; which may be further confirmed by what he formerly noted of the sudden damps, that happen in many mines. But that, which is of the most importance about our present inquiry, remains yet to be mentioned; which is, that having had the curiosity to inquire, whether no body else had made experiments of the same kind; I find, that the learned *Maignan* had the same curiosity, that *Zucchi* had, but with very differing success; and therefore, though this inquisitive person do admit, in his disputation about *Antiperistasis*, a notion, that I confess I cannot approve, (since to ascribe, as he does, a *fuga contrarii* * to cold and hot spirits, is, in my apprehension, to turn inanimate bodies

See the second preliminary discourse, that accompanies the History of Cold.

* My backwardness to admit a *fuga contrarii* may be somewhat confirmed by what I lately learned from the English extraordinary ambassador (the earl of *Carlisle*) into *Russia*, newly returned thence. For meeting the other day with an opportunity of asking his lordship a few questions (which he was pleased to answer with his wonted civility) about the cold in *Muscovy*; I was informed by one of his answers, that his excellency had there the curiosity to observe some bottles of choice and strong wine, that were vehemently frozen, and the opportunity to take notice, that the liquor was quite congealed throughout, and turned into solid ice: whence he rationally inferred, that the spirituous parts of wine did not in these bottles (for aught he acknowledged, that in greater vessels, that may sometimes hold true, which is said of the production of spirit of wine by congelation) retire to the centre, and remain there unfrozen. And his lordship ingeniously pursued the experiment, and confirmed the conjecture, by causing the ice to be taken out of the broken bottles, to be thawed by degrees into several vessels, by which means he found, that the liquor afforded by the exterior parts of the resolved ice was very little, if a less strong, than that, which was obtained from the internal parts of the same ice. From which observation *Carneades* would argue, that at least it is not universal, but in particular cases, and therefore probably by accident, or upon particular accounts, that the concentration of the spirits of liquors is consequent upon being exposed to cold.

into

into intelligent and designing beings) yet he does justly and rationally reject, with *Carneades*, the vulgar doctrine of Antiperistasis, and confirms his rejection of it by two experiments. For first, he says, that he found with a thermometer, that when in winter a cold northerly wind froze the water without doors, it was no less cold in wine-cellars, than it was at the same season, and at the same hour of the day in his study, only the paper-shuts of his window, that regarded likewise the North, being put to. And though, if he had said nothing else, I should have suspected, that this might have proceeded from the shallowness of the cellars he made his trial in; yet he prevents that suspicion, by taking notice in one clause of his relation, that the cellars were of the very best of their kind, in which in summer the greatest cold was wont to be felt. But his next experiment is yet more considerable, which I shall therefore deliver in his own words that follow: *Expertus ego sum* (says he) *thermometro fidelissimo, & à præcedente hyeme in sequentem æstatem prorsus invariato, instructo etiam tali aquâ, nempe in hoc ipsum ex præscripto Trebellii, ita comparata, ut non exhaletur, neque minuatur; expertus (inquam) sum in supradictis optimis cellis vinariis maximum, quod ardentissima æstate fuit, frigus non adæquasse illud, quod ibidem erat brumali tempore, ut dixi in superiori experimento, siquidem in tubo vitrei thermometri quatuor circiter palmos longo, & in octo gradus graduumque minuta diviso, æqua hyeme ascendit ad gradus 7. cum semisse, æstate autem vix gradum sextum superavit, cum tamen ad sensum multa magis vigeret frigus istud æstrum.*

Thus far this learned, as well as resolute author, who seeming, by the mathematical part of his *Perspectiva Horaria*, to be an accurate and industrious maker of observations, we may oppose this newly-recited experiment to that of *Zucchi*, which it flatly contradicts: and therefore since the depth of the cellars is of great moment in experiments of this nature; since also the particular parts of the place or soil, where the cellars or other cavities happen to be, may, in some cases, not be inconsiderable; and since lastly, neither *Zucchi* or *Maignan* seem to have been aware of the differing weights of the atmosphere, in the self-same place, (as not having seen the XVIIIth of our *Physico-mechanical Experiments*, before which I never saw nor heard of any thing published, or otherwise written to that purpose) I hope I shall be excused, if I retain some scruples about the historical question I have been considering, till the experiment have been carefully made, for a competent space of time in several places, and that not with common weather-glasses (like those used by my two learned authors) wherein the liquor may be made to rise and fall by the differing gravities of the air, but with sealed thermoscopes, wherein the alterations may more safely be supposed to proceed only from its heat and cold.

And to conclude, since *Carneades* has speciously enough answered the other observations, that are wont to be produced in favour of the Aristotelian Antiperistasis, if *Maignan*'s relation be better warranted by future experiments, than that of *Zucchi*, it will very much disavour the whole doctrine itself, which seeming to have been devised, but to give an account of the phænomena, to which it is wont to be applied, considering men will be but little invited to imbrace it, if the matter of fact be as little certain, as what is proposed in the hypothesis is intelligible.

A N
E X A M E N

O F

Mr. HOBBS'S Doctrine touching COLD.

A D V E R T I S E M E N T.

THE author of the following discourse intending it should make a part of certain considerations upon the four famous hypotheses, or opinions, of the Nature and Cause of Cold; which (considerations) he thought fit to reserve for the latter end of the history of that quality, was invited to suppress it ever since the former part of the year, that preceded the last. And though this discourse, (both for other reasons, and because he found it more ready and finished, than some other papers, that belonged to the same part of the newly mentioned history) comes abroad unaccompanied; yet he judged it not amiss, to intimate thus much, that the reader may be informed, upon what account Mr. *Hobbes's* opinions come to be examined in an historical treatise; and may not wonder either to find, that divers passages of it are omitted, that are unfavourable enough to Mr. *Hobbes's* doctrine, or to meet with in a discourse postponed to the *History of Cold* some experiments, that seem to argue it to have been written before they were cast into the order, wherein they now appear. To this I have nothing to add, but that whereas through haste the scheme referred to in the long citation out of Mr. *Hobbes's* has not been added to the others, that belonged to this book, I am not much troubled at the omission (as also that in other quotations the place is not always as well mentioned as the words) because, that if any shall be found, that after having considered, what I urge against the (great, but imaginary) interest, Mr. *Hobbes* would ascribe to winds (whether he explicate their causes rightly or not) in the production of lesser degrees of cold, but (how improbably soever) of congelation itself, shall think the sight of that scheme of any importance; this learned man's book, *De Corpore*, is in so many hands, that any reader shall desire it, may very easily have an opportunity to consult the scheme in the particularly cited place.

1. MR. *Hobbes's* Theory concerning Cold does to me, I confess, appear so inconsiderately pitched upon, and so slightly made out, that I should not think it merited, especially in an historical treatise, a particular or serious examination, but that in proposing it, he scruples not to talk to his readers of his demonstrations; and the preference he is wont to give himself above the eminentest, as well of modern as of ancient writers, has had no small effect upon many, who not knowing, how indulgent some writers are wont to be to the issues of their own brain; as such, are apt to mistake confidence for evidence, and may be modest enough to think, that their not discerning a clearness in his explications and reasonings, is rather a fault of their understandings, than of his doctrine. Mr. *Hobbes* delivers his theory in the seven first articles of the 28th chapter of the fourth part of his elements. But
because

because the whole discourse is too long to be here transcribed, and because in the 2d, 3d, and 4th sections, that, which he treats of, is the generation of winds, and, that which he handles in the 5th, is the notion of a hard body; we may safely leave out those four sections, especially since, though there be in them divers things about the motion of the sun, and other matters, that are more strongly asserted than proved, yet his doctrine tending but to shew, how the winds are generated, though it were granted, would make but very little, if any thing at all, towards the evincing of his theory about cold.

2. AND that we may not be suspected to injure his opinion or his arguments, we will, though the citation will be somewhat prolix, first recite them, as himself delivers them in those three sections, that treat immediately of cold, and then we will subjoin our animadversions on them.

Artic. 6.

3. [THESE things, says he, being premised, I shall shew a possible cause, why there is greater cold near the poles of the earth, than further from them. The motion of the sun between the tropicks, driving the air towards that part of the earth's superficies, which is perpendicular under it, makes it spread itself every way; and the velocity of this expansion of the air grows greater and greater, as the superficies of the earth comes more and more to be straitned; that is to say, as the circles, which are parallel to the equator, come to be less and less. Wherefore this expansive motion of the air drives before it the parts of the air, which are in its way, continually towards the poles more and more strongly, as its force comes to be more and more united, that is to say, as the circles, which are parallel to the equator, are less and less; that is, so much the more, by how much they are nearer to the poles of the earth. In those places therefore, which are nearer to the poles, there is greater cold, than in those, which are more remote from them. Now this expansion of the air upon the superficies of the earth from east to west doth by reason of the sun's perpetual accession to the places, which are successively under it, make it cold at the time of the sun's rising and setting: but as the sun comes to be more and more perpendicular to those cooled places, so by the heat, which is generated by the supervening simple motion of the sun, that cold is again remitted, and can never be great, because the action, by which it was generated, was not permanent. Wherefore I have rendered a possible cause of cold in those places, that are near the pole, or where the obliquity of the sun is great.

Artic. 7.

4. How water may be congealed by cold, may be explained in this manner. Let A (in the first figure) represent the sun, and B the earth; A will therefore be much greater than B. Let E F be in the plain of the equinoctial, to which let G H I K and L C be parallel. Lastly let C, and D, be the poles of the earth. The air therefore by its action in those parallels will rake the superficies of the earth, and that with a motion so much the stronger, by how much the parallel circles towards the poles grow less and less. From whence must arise a wind, which will force together the uppermost parts of the water, and withal raise them a little, weakening their endeavour towards the center of the earth. And from their endeavour towards the center of the earth, joined with the endeavour of the said wind, the uppermost parts of the water will be pressed together and coagulated; that is to say the top of the water will be skinned over and hardened, and so again the water next the top will be hardened in the same manner, till at length the ice be thick. And this ice being now compacted of little hard bodies, must also contain many particles of air received into it. As rivers and seas, so also in the like manner may the clouds be frozen. For when by the ascending and descending of several clouds at the same time, the air intercepted between them is, by compression, forced out, it rakes, and by little and little hardens

hardens them. And though those small drops (which usually make clouds) be not yet united into greater bodies, yet the same wind will be made; and by it, as water is congealed into ice, so will vapours in the same manner be congealed into snow. From the same cause it is, that ice may be made by art, and that not far from the fire; for it is done by the mingling snow and salt together, and by burying in it a small vessel full of water. Now when the snow and salt (which have in them a great deal of air) are melting, the air, which is pressed out every way in wind, rakes the sides of the vessel; and as the wind by its motion rakes the vessel, so the vessel by the same motion and action congeals the water within it.

5. WE find by experience, that cold is always more remiss in places, where it rains, and where the weather is cloudy (things being alike in all other respects) than where the air is clear. And this agreeth very well with what I said before; for in clear weather the course of the wind, which (as I said even now) raked the superficies of the earth, as it is free from all interruption, so also it is very strong. But when small drops of water are either rising or falling, that wind is repelled, broken and dissipated by them; and the less the wind is, the less is the cold.

6. WE find also by experience, that in deep wells the water freezeth not so much, as it doth upon the superficies of the earth. For the wind, by which ice is made, entering into the earth (by reason of the laxity of its parts) more or less, loseth some of its force, though not much. So that if the well be not deep, it will freeze; whereas if it be so deep, as that the wind, which causeth cold, cannot reach it, it will not freeze.

7. WE find moreover by experience, that ice is lighter than water, the cause whereof is manifest from that, which I have already shown, namely, that the air is received in, and mingled with the particles of the water, whilst it is congealing.

8. To examine now Mr. *Hobbes's* theory concerning cold, we may in the first place take notice, that his very notion of cold is not so accurately, nor warily delivered. I will not here urge, that it may be well questioned, whether the tending outwards of the spirits and fluid parts of the bodies of animals do necessarily proceed from, and argue heat. Since in our pneumatical engine, when the air is withdrawn from about an included viper (to mention no other animals) there is a great intumescence, and consequently a greater endeavour outwards of the fluid parts of the body, than we see made by any degree of heat of the ambient air, wont to be produced by the sun. This, I say, I will not insist on, but rather take notice, that though Mr. *Hobbes* tells us, that to cool, is to make the exterior parts of the body endeavour inwards; yet our experiments tell us, that when a very high degree of cold is introduced, not only into water, but into wine, and divers other partly aqueous liquors, there is a plain intumescence, and consequently endeavour outwards of the parts of the refrigerated body. And certainly cold having an operation upon a great multitude and variety of bodies, as well as upon our sensories, he, that would give a satisfactory definition of it, must take into his consideration divers other effects, besides those it produces on human bodies. And even in these, he will not easily prove, that in every case any such endeavour inwards from the ambient æthereal substance, as his doctrine seems to suppose, is necessary to the perception of cold; since, as the mind perceives divers other qualities, by various motions in the nervous or membranous parts of the sentient; so cold may be perceived, either by the decrement of the agitation of the parts of the object, in reference to those of the sensory; or else by some differing impulse of the sensitive parts occasioned by some change made in the motion of the blood.

blood or spirits, upon the deadening of that motion; or by the turbulent motion of those excrementitious steams, that are wont, when the blood circulates as nimble, and the pores are kept as open as before, to be diffipated by insensible transpiration.

9. It may afford some illustration to this matter to add, that having inquired of some hysterical women, who complained to me of their distempers, whether they did not sometimes find a very great coldness in some parts of their heads, especially at the top, I was answered, that they did so; and one of them complained, that she felt in the upper part of her head such a coldness, as if some body were pouring cold water upon it. And having inquired of a couple of eminent physicians, of great practice, about this matter, they both assured me, that many of their hysterical patients had made complaints to them of such great coldness in the upper part of the head, and some also along the vertebrae of the neck and back. And one of these experienced doctors added, that this happened to some of his patients, when they seemed to him and to themselves to be otherwise hot. The noble * *Avicen* also somewhere takes notice, that the invenomed bitings of some kinds of serpents, (creatures too well known in the hot countries, where he lived) made those, that were bitten by them, either become or think themselves very cold. But that will perhaps seem more remarkable, which I shall further add, namely, that I know a nobleman, who followed the wars in several countries, and has signalized his valour in them; and yet though his stature be proportionate to his courage, yet when this person falls (as frequently he has done) in a fit of the stone, he feels an universal cold over his whole body, just like that, which begins the fit of an ague. And though he assures me, that the stones, that torment him, and which he usually voids, are but very small; yet whilst the fit continues, which oftentimes last many hours, he does not only feel an extraordinary coldness, but which is more strange, and which I particularly inquired after, cannot by clothes, or almost any other means, keep himself warm.

10. I ELSEWHERE take notice of some other observations, agreeable to these, by some of which we may be persuaded, that there may be other ways, besides those already mentioned, of perceiving cold, though the outward parts of our bodies were not pressed inwards. And whereas Mr. *Hobbes* infers that he, who would know the cause of cold, must find by what motion or motions the exterior parts of any body endeavour to retire inwards, that seems but an inconsiderable direction. For in compressions, that are made by surrounding bodies, there is produced an endeavour inward of the parts of the compressed body, though no cold, but sometimes rather heat be thereby generated. And I hope Mr. *Hobbes* will not object, that in this case the parts do not retire, but are thrust inwards, since, according to him, no body at all can be moved, but by a body contiguous and moved. But what I have hitherto taken notice of, being chiefly designed to shew, that the notion of cold in general is not so obvious a thing to be rightly pitched upon, as many think, and that therefore it needs be no wonder, that it hath not been accurately and warily proposed by Mr. *Hobbes*; I shall not any further prosecute that discourse, but proceed to what remains. Next then, the cause he assigns; why a man can blow hot or cold with the same breath, is very questionable; partly, because he supposes in part of the breath such a simple motion, as he calls it, of the small particles of the same breath, as he will not easily prove, and as † eminent astronomers and mathematicians have rejected; and

* Quoted by Paul Neweraatz. *De Purpura*, cap. 12.

† Dr. S. Ward, (now the worthy bishop of Exeter) and Dr. Wallis, the learned Savilian professor of Geometry, &c.

partly,

partly, because that without the suspected supposition, I could (by putting together the conjectures of two learned writers, and what I have elsewhere added of my own) give a more probable account of the phænomenon, if I had not some scruples about the matter of fact itself: which last clause I add, because, though I am not sure, that further trials may not satisfy me, that the wind or breath, that is blown out at the middle of the compressed lips, has in it such a real coldness, as men have generally ascribed to it, yet hitherto some trials, that my jealousy led me to make, incline me to suspect, there may be a mistake about this matter, and that in estimating the temper of the produced wind, our senses may impose upon us. For having taken a very good and tender sealed weather-glass, and blown upon it through a glass pipe (of about half a yard long) that was chosen slender, to be sure, that my breath should issue out in a small stream; by this wind beating upon the ball of the weather-glass, I could not make the included spirit of wine subside, but manifestly, though not much ascend, though the wind, that I presently blew through the same pipe, seemed sensibly cold, both to the hand of by-standers, and to mine own, and yet mine was more than ordinarily cold. So that having no great encouragement to enter into a dispute about the cause of a phænomenon, whose historical circumstances are not yet sufficiently known and cleared, I will now proceed to add, that whatever be the cause of the effect, there are divers things that make Mr. *Hobbes's* hypothesis of the cause of cold unfit to be acquiesced in. For we see, that the grand cause he assigns of cold and its effects, is wind, which, according to him, *is air moved in a considerable quantity, and that either forwards only, or in an undulating motion*: and he tells us too, that when the breath is more strongly blown out of the mouth, then is the direct motion prevalent (over the simple motion) which, says he, makes us feel cold; for, says he, the direct motion of the breath or air is wind, and all wind cools or diminishes former heat. To which words in the very next line he subjoins, that not only great, but almost any ventilation, and stirring of the air doth refrigerate. But against this doctrine I have several things to object.

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11. For first, we see there are very hard frosts, not only continued, but oftentimes begun, when the air is calm and free from winds; and high and boisterous southerly winds are not here wont to be near so cold as far weaker winds, that blow from the North-east.

12. NEXT, if Mr. *Hobbes* teach us, that it is the direct motion of the stream of breath, that is more strongly blown out, that makes us feel cold, he is obliged to render a reason, why in an æolipile with a long neck, the stream, that issues out, though oftentimes far stronger than that, which is wont to be made by compressing the lips, at a pretty distance from the hole it issues out of, is not cold, but hot.

13. THIRDLY, Mr. *Hobbes* elsewhere teaches, that when in our engine the pump has been long employed to exhaust, as we say, the receiver, there must be a vehement wind produced in that receiver; and yet by one of our other experiments it appeared, that for all this in a good sealed weather-glass placed there, before the included air begins to be, as we say, emptied, there appeared no sign of any intense degree of cold produced by this supposed wind, so that either the wind is but imaginary, or else Mr. *Hobbes* ascribes to winds, as such, an infrigidating efficacy, that does not belong to them.

14. FOURTHLY, we find by experience, that in hard frosts water will freeze, not only though there be no wind stirring in the ambient air, but though the liquor be kept in a close room, where, though the wind were high abroad, it could not get admittance; and some of our experiments, carefully made, have assured us, that

water sealed up in one glass, and that glass kept suspended in another glass carefully stopp'd, to keep out not only all wind, but all adventitious air, may nevertheless be not only much cooled, but turned into ice.

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15. FIFTHLY, We found by other experiments, that a frozen egg, though suspended in, and perfectly surrounded with water, where no wind can come at it, will be every way crusted over with ice; in which case there is no probability, that the ice should be generated according to the way proposed by Mr. *Hobbes*. For he will scarce prove, nor is there any likelihood, that a wind pierced the shell and closer coats of the egg to get into the contained liquors, and freeze them: and a more unlikely assertion it would be, to pretend, (as he, that maintains Mr. *Hobbes*'s doctrine, must) that so very little air, if there be any, as is mingled with the juices of the egg, is, by the cold, which is not wont to expand air (nor water, till it be ready to make it freeze) turned into a wind subtle enough, freely to penetrate the shell and coats of the egg, and great enough to diffuse itself every way, and turn on every side the neighbouring water into ice; and all this notwithstanding, that not only it appeared not by bubbles breaking through the water, that there is any adventitious air, that comes out of the egg at all; but that also, supposing there were some such contained in the egg, yet what shadow of reason is there to conceive, that the air which was engaged in, and surrounded with the substances of the white, and the yolk of the egg, must needs be a wind, since, according to Mr. *Hobbes*, that requires a considerable motion of most of the parts of the moved air the same way, and, according to him also, a body cannot be put into motion, but by another body contiguous and moved.

16. SIXTHLY, Mr. *Hobbes* does indeed affirm, that all wind cools, but is so far from proving, that the highest degrees of cold must needs proceed from wind, that he does not well evince, that all winds refrigerate. Nor are we bound to believe it without proof, since wind being, according to him, but air moved in a considerable quantity, either in a direct or undulating motion, it does not appear, how motion should, rather than rest, make air grow cold. For though it be true, that usually winds seem cold to us; yet, in the first place, it is not universally true, since some, that have travelled into hot countries, and particularly the learned * *Alpinus*, have complained, that the winds coming to them in the summer from more torrid regions have appeared to them almost like the steam that comes out at the open mouth of a heated oven. And if † *Marcus Polus Venetus* be to be credited, (for I mention his testimony but *ex abundanti*) the southern winds near *Ormus* have been sometimes so hot, as to destroy an army itself at once. And secondly, even when the wind does feel cold to us, it may oftentimes do so but by accident; for, as we elsewhere likewise teach, the steams, that issue out of our bodies being usually warmer than the ambient air, (whence in great assemblies, even those, that are not thronged, we find it exceeding hot, and I have several times observed a hot wind to come from those throngs, and beat upon my face) and the more inward parts of our bodies themselves being very

* *Euri, austrique venti à meridie loca arenosa summoque calore inflammata transeuntes, atque Ægyptum spirantes, tantum caloris æstus, pulverumque & inflammatarum arenarum evocunt, ut ignitas fornacis flammæ, nec non pulveribus obscurissimas nubes eo asportasse videatur.* And elsewhere: *Prima æstatis parte calidissima inæqualissimaque ob vehementissimum meridionalium ventorum calorem, &c.* Prosper *Alpinus de Medicina Ægyptiorum.*

† From nine till noon, there blows a wind with such extreme heat from the sands, that it swallows up a man's breath, and stifles him. The King of *Chermain* sent an army of sixteen hundred horse, and five thousand foot, against the Lord of *Ormus*, for not paying his tribute, which were all surprised and stifled with that wind. *Marcus Polus in Purchas's Pilgrims, lib. 111. p. m. 71.*

much hotter than the ambient air, especially that, which is not yet full of warm steams, the same causes, that turn air into a wind, put it into a motion, that both displaces the more neighbouring and more heated air, and also makes it pierce far deeper into the pores of the skin, whereby coming to be sensible to those parts, that are somewhat more inward than the cuticula, and far more hot, the air turned into wind seems to us more cold, than the restagnant air (if I may so speak) upon such another account as that, upon which, if a man has one of his hands hot, and another not, the same body that will appear lukewarm to this, will appear cold to the other; because, though the felt body be the same, yet the organs of feeling are differently disposed. And to confirm this doctrine by an experiment, (which has succeeded often enough, and need not succeed always to serve our present purpose) we will add, that though air blown through a pair of bellows upon one's hand, when it is in a moderate temper, will seem very cold; yet, that the ambient air by being thus turned into wind, does indeed acquire a relative coldness, so as to seem cold to our senses, but yet without acquiring such a cold as is presumed, may appear by this, that by blowing the same air with the same bellows upon weather-glasses, though made more than ordinarily long, and by an artist eminent at making them, we could not observe, that this wind's beating upon them did sensibly refrigerate either the air, or the liquor. Though it is not impossible, but that in some cases the wind may cool even inanimate bodies, by driving away a parcel of ambient air, impregnated with exhalations less cold, than the air that composes the wind. But this is not much, if at all, more than would be effected, if, without a wind, some other body should precipitate out of the air near the weather-glass, the warmer effluvia we have been mentioning; especially if the precipitating body introduce in the room of the displaced particles, such as may in a safe sense be termed frigorisick.

See this difficulty more largely handled in the first preliminary discourse.

17. SEVENTHLY, nor can we admit, without a favourable construction, Mr. *Hobbes's* way of expressing himself, where he says, as we have lately seen, that all wind cools or diminishes former heat. For if we take heat in the most common sense, wherein the word is used, not only by other writers, but also by philosophers, to make wind the adequate cause of cold, it must in many cases do more than diminish former heat. For water, for instance, that is ready to freeze, is already actually cold in a high degree, and yet the wind (if Mr. *Hobbes* will needs have that to be the efficient of freezing) must make this not hot, but already very cold liquor, more cold yet, before it can turn into ice.

18. THESE things thus established, it will not be difficult to dispatch the remaining part of Mr. *Hobbes's* theory of cold. For, to proceed to his sixth section, we shall pass by what a cosmographer would perhaps except against in his doctrine about the generation and motion of the wind upon the surface of the earth, and shall only take notice in the remaining part of that section of thus much: That the most of what Mr. *Hobbes* here shews us, is but, that there is an expansion of the air, or a wind generated by the motion and action of the sun; but why this wind thus generated must produce cold, I do not see, that he shews; nor does his affirming, that it moves towards the poles, help the matter. For besides that we have shewn, that wind, as such, is not sufficient to produce far less degrees of cold, than those, that are felt in many northern regions, there must be some other cause, than the motion of the air or steams driven away by the sun, to make bodies, not in themselves cold, (for so they were supposed not to be, when the sun began to put them in motion) become vehemently cold in their passage. For Mr. *Hobbes* cannot, as other naturalists, derive the coldness of freezing winds from the cold steams they meet with, and carry along with them in their passage through cold regions; since then those steams rather than the
wind

wind would be the cause of that vehement coldness; and so it might justly be demanded, whence the coldness of these cold exhalations proceeds. Besides that, it is very precarious and unconsonant to observation, to imagine such a wind, as he talks of, to blow, whenever great frosts happen, since, as we noted before, very vehement glaciations may be observed, especially in northern regions, when the air is calm, and free from winds.

19. THE account he gives in his seventh section of turning water into ice, is the most unsatisfactory I have ever yet met with; for a good part of that section is so written, as if he were afraid to be understood. But whereas he supposes, that by the endeavour of the wind to raise the parts of the water, joined with the endeavour of the parts of the water towards the center of the earth, the uppermost parts of the water will be prest together, and coagulated, he says that which is very far from satisfactory. For, first, ice is often produced, where no wind can come to beat upon the uppermost parts of the water, and to raise them; and in vessels hermetically sealed, which exactly keep out air and wind, ice may be generated, as many of our experiments evince. And this alone were a sufficient answer, since the whole explication is built upon the action of the wind. But this is not all we have to object; for not to urge, that he should have proved, that the uppermost parts of the water must be raised in congelation, especially since oil, and divers other liquors, are contracted by it; not to urge this, I say, what shew of probability is there, that by the bare endeavour of the wind, and the gravity of the superficiale parts of the water, there should be any such forcible compression made, as he is pleased to take for granted? And yet this itself is less improbable, than that supposing the uppermost parts of the water to be pressed together, that pressure is sufficient to coagulate, as he speaks, or rather congeal them into ice. So bold and unlikely an assertion should at least have been countenanced by some plausible reason, or an example in some measure parallel. For I remember not any one instance, wherein any degree of compression, that has been employed, much less so slight a one as this must be, considering the causes, whence it is said to proceed, can harden any liquor, into ice, or any other hard body. And in the experiment, we have elsewhere mentioned, of filling a pewter vessel with water, and when it is exactly closed, compressing it by the knocks of a hammer, till the water be reduced to penetrate the very pewter, we found not that so violent a compression did give the water the least disposition to turn a hard body. And as for the way Mr. *Hobbes* assigns of increasing the thickness of ice, it is very difficult to conceive, how a cake of ice on the top of the water, being hard frozen to the sides of the containing vessel, and thereby severing betwixt the included water and the external air; the wind, that cannot come to touch the water, because of the interposition of the hard and rigid ice, should yet be able; sometimes at the depth of nine or ten foot, or much further, to beat upon the subjacent water, and turn it into ice. And it is yet more difficult to conceive, how the wind must do all this, when, as was lately noted, the water doth freeze more and more downwards, to a great depth, in places where the wind cannot come to beat upon it at all. And as to what Mr. *Hobbes* further teaches, that the ice must contain many particles of air received into it, we have elsewhere occasion to show, how erroneously he discourses about those icy bubbles.

20. THE reason he assigns of the freezing of water with snow and salt, does as little satisfy as the rest of his theory of cold. For not to mention, that he affirms, without proving it, that snow and salt have in them a great deal of air; it is very precarious to assert, that this air must be prest out every way in wind, which must rake the sides of the vessel: for it is strange, that far more diligent observers than Mr. *Hobbes* should

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In the new
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of the air.

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take no notice of any such wind, if any such wind there were. But this is yet less strange than that which follows; namely, that this wind must so rake the sides of the vessel, as to make the vessel, by the same motion and action, congeal the water within it: for what affinity is there between a wind passing along the outside of a glass, altogether impervious to it, and the turning a fluid body, included in that glass, into a hard and brittle body? The wind indeed may, perhaps, if it be strong, a little shake or agitate the particles, that compose the glass, and those may communicate some of their motion to the contiguous parts of the water: but why all this must amount to the turning of that water into ice, is more, I confess, by far than I can apprehend; especially seeing, that though you long blow upon a glass of water with a pair of bellows, where there is not an imaginary wind, as Mr. *Hobbes's*, but a real and manifest one; yet the water will be so far from being frozen, that our formerly mentioned experiments (of blowing upon thermometers) make it probable, that it will scarce be cooled. And if sea-salt do contain so much air, by virtue of which, it, as well as the snow, produces so intense a degree of cold, how chance, that being resolved in a little water without snow, it does not produce at least a far greater degree of cold than we find it to do? Besides, in the experiment we made (and elsewhere mention) of freezing water sealed up in bubbles, though the bubbles were suspended in other glasses, whose sides now here touched them, and the remaining part of whose cavities were filled some with air, and some with unfreezing liquors; what likelihood is there, that Mr. *Hobbes's* insensible wind should be able to occasion so many successive rakings through different bodies, as there must be, to propagate the congelative motion (if I may so call it) of the wind, through the first glass, to the included air or liquor, and through that new medium to the glass containing immediately the water, and through that to the innermost parts of the sealed up water? And it might be further objected, if it were worth while, that Mr. *Hobbes* does not so much as offer at a reason, why spirit of wine, aqua fortis, or even brine, if it be of the strongest fort, are not either by this mixture, or (here in *England*) by the wind in open air, turned into ice, as well as many other liquors are.

See the 4th
Section of
the History
of Cold.

21. THE reason, why cold is wont to be more remiss in rainy or cloudy weather, than in that which is more clear, is not better given by Mr. *Hobbes*, than by some others, that have written before him: for, not to mention, that I have seen great frosts, and lasting enough in cloudy, and sometimes very dark weather, that which he talks of the wind's being more strong in clear weather than in cloudy, is of no great importance; since common experience shews, that in clear weather the air may be very cold, and the frost very great, where no wind is felt to rake (as he would have it) the superficies of the earth. Nor does experience bear witness to what he not warily enough pronounces, that the less the wind is, the less is the cold. There are but two phænomena more, which in this section Mr. *Hobbes* pretends to explicate: the one is, that in deep wells the water does not freeze so much, as it does upon the superficies of the earth. But the reason of this we elsewhere take occasion to consider, and therefore in this place we need only note, that Mr. *Hobbes* has not rightly assigned it, by ascribing it to the wind's entering more or less into the earth, by reason of the laxity of its parts; since besides that it is very improbable, that the wind should not, as he says it does not, lose much of its force by entering into the earth at its pores, and other lesser cavities (for that seems to be his meaning by the laxity of the earth's parts) to so great a depth as water lies in several wells subject to freezing: besides this, I say, experience teaches us, that wells may be frozen, though their orifices be well covered, and the wind be thereby kept from approaching the included water by divers yards; and very many wells, that are subject to freeze, when northerly and easterly

See the
Examen of
Antiperi-
stasis.

easterly winds reign, will likewise be frozen in very cold winters, whether any winds blow, or not.

22. THE other, and last phænomenon, Mr. *Hobbes* attempts to explicate, is, that ice is lighter than water. The cause whereof, says he, is manifest from what I have already shown; namely, that air is received in, and mingled with the particles of the water, whilst it is in congealing. But that this is not the true reason, may be argued from hence, that if a convenient glass-vessel be filled topfull with water, and exposed either unsealed or sealed to congelation, the ice will have store of bubbles, which, at least in the sealed vessel, cannot by Mr. *Hobbes*, who will not affirm glass to be pervious to the air, be pretended to proceed from bubbles, that got from without into the water, whilst it was in congealing. And we have sometimes had occasion to manifest, by particular experiments purposely made, how little of air there is even in those bubbles, that are generated in ice, made in vessels, where the air was not kept from being contiguous to the water.

See the 9th
Title of the
History of
Cold.

23. AND thus have we gone through Mr. *Hobbes's* theory of cold. In his proposing of which, we wish'd he had in divers places been more clear; and in our cursory examination of which we have seen, that most of the particulars are either precarious or erroneous; and were they neither, yet the whole theory would, I fear, prove very insufficient. Since an attentive reader cannot but have marked, that this learned author has past by far the greatest part even of the more obvious phænomena of cold, without attempting to explicate them, or so much as shewing in a general way, that he had considered them, and thought them explicable by his hypothesis: by which he, that will fairly explain all the phænomena recited in the notes we have been drawing together, and which yet contain but a beginning of the History of Cold, shall give me a very good opinion of his sagacity.

A P O S T S C R I P T.

THOUGH the haste I am obliged to comply with, keep me from annexing the historical papers, wherewith I had thoughts to conclude this book, concerning cold; yet since the nature of the past Examen gave me but little opportunity to teach the reader any thing more considerable, than that Mr. *Hobbes's* doctrine is erroneous; I am very inclinable to make him here some such little amends, as the time will permit, for that paucity of experiments. And therefore since in the last section of the foregoing History, upon occasion of an experiment very imperfectly, and not intelligibly delivered by *Berigardus*, I intimate my having elsewhere plainly set down either the same he meant, or one of that nature, and that with considerable phænomena unmentioned by him; I chuse rather to borrow some account of it from another treatise, to which it belongs, than not to gratify some of the curious to whom the phænomena I shewed them of it, seemed no less pretty than surprizing.

THE way then I used in making this experiment, may be gathered from the following directions.

TAKE of good unflaked lime three parts (or * thereabouts) of yellow orpiment one part, of fair water 15 or 16 parts; beat the lime grossly, and powder the orpiment.

* According to the goodness of the lime, of which, if it be very strong, two parts may serve the turn; and which, if it be too weak, may make the experiment miscarry.

(with

(with care to avoid the noxious dust, that may fly up *) and having put these two ingredients into the water, let them remain there for two or three hours, or longer, if needs be, remembring to shake or stir the mixture from time to time. By this means you will obtain a somewhat fetid liquor, whereof by warily decanting, or by filtrating it, the clear part must be severed from the rest.

In the mean time, take a piece of cork, and having lighted it so, that it is kindled throughout, remove it from the fire, whilst it is yet burning, and by a quick immersion quench it in fair water. And having by this means reduced it to a coal, you may (in case you have not erred in the operation) by grinding it with a convenient quantity of gum-water †, bring it to the colour and consistence of a good black ink, that you may use with an ordinary pen.

WHILST these things are doing, you may take what quantity you think fit of common minium ‡, and two or three times its weight of spirit of vinegar, (which needs not be for this purpose much stronger than phlegm, and to which even undistilled vinegar may be a succedaneum) and putting the powder and liquor into a glass phial, or any other convenient vessel, let them infuse over hot embers, or in some considerably warm place for two or three hours more or less, till the liquor have acquired a very sweet taste.

ALL things being thus prepared, take a new, or at least a clean pen, and write with it some such thing, as you either desire or need not fear to have read, between (if you please) or, which is safer, || over the lines, which contain your secret, and which are to be traced with the solution of minium; for this liquor, if it be either well decanted or filtered, will be so clear, that what is written with it by a new pen, will not be seen on the paper when it is dry.

LASTLY, When you would show the experiment, dip a small piece of sponge, or a linen-rag (or, for a need, a little paper wreathed) in the water, that was made with lime and auripigmentum, and with this liquor, which, though it smell ill, will look limpid and clear, wiping over the paper, it will presently, at once, both wipe out or obliterate what was written with the black ink, and make all that was written with the invisible ink, though perhaps in the self-same lines, appear black, so as to be very easily and plainly legible.

THIS is the way, to which many years ago my trials led me, of making this odd experiment. For the performing whereof, if any can propose a more easy and better way, (for I find by an inquisitive § traveller, that there are more ways than one) I shall willingly learn it. In the mean time, the reader may perceive, that I did not causlessly intimate, that the learned *Berigardus*, though he would manifest a great thing in philosophy by this experiment, did yet either not understand himself that part of it he pretends to teach, or has omitted one of the main ingredients of the water of orpiment he speaks of. For I did not find, that even by a long infusion,

* To prevent which, I usually cause the orpiment to be beaten, wrapt up in divers papers, or some other way secured from avolation, and from harming the vessel wherein it is pounded.

† Which for this use it will suffice to make by dissolving gum-arabick in a little fair water.

‡ This is known in the shops by the name of red lead, and is here specified, as being cheap and easy to be procured, though I suppose, that other calxes or powders of the same metal, if they be not sophisticated, may serve the turn.

|| If you write first with the black ink, and then with the solution, the lines must be made somewhat distant, that those, which express your secret, may have room between the others; and therefore the better to avoid suspicion, I chose rather to write first with the invisible ink, and then over that with the black, as if I had writ on an ordinary piece of white paper, by which means I could write the black lines as close as I pleased.

§ That learned gentleman Mr. *H. Oldenburg*, secretary to the Royal Society.

nor by some decoction of the orpiment alone (without the quick-lime) there would be produced a liquor, either obviously fetid, or that would perform so much as a less matter, than what that, which he mentions, should. And whereas he seems to commend this way (though but between lines written with common ink) for the writing of things one would not have to be discovered, and though I have yet met with nobody, that having seen the experiment, is not of his mind; yet I remember, that when, many years ago, I was making trials concerning the several ways of making invisible inks, my conjectures led me to discover, that I could very readily bring what was written, with a solution of minium, to be legible by the help of a fire; as well as I could also detect by the same way several invisible inks, which are believed to require appropriated liquors to make them confess their secrets. But I must reserve the reflections, and other particulars, that relate to this experiment, for the treatise, to which it belonged. Only I will now add, that besides the above-specified motives to communicate what I have at present written of it, I was the rather induced to do so, because I had mentioned, but not taught this experiment, in the History of Whiteness and Blackness; and because also *Berigardus* is not the only author of note I have met with, that having made particular mention of the experiment, has given the curious but a lame and unsatisfactory account of it.

ADVERTISEMENT to the READERS

Of the following EXPERIMENTS,

By the AUTHOR of the foregoing HISTORY.

AT the same time that the Royal Society required of me an account of what I had observed, or tried, concerning Cold *, they recommended the making of trials about that subject to the learned Dr. C. Merret, who having dispatched what he intended, much earlier than I could bring in my far more voluminous papers, he long ago presented his to that Illustrious Company: and since that, has thought fit to let them indear my treatise, by their being annexed to it, and composing a part of it; and that such a part, as much might be said of it, if after I have informed the reader of its having obtained the thanks of a society, that is too much accustomed to receive and produce excellent things, to be suspected of valuing trifles, I could think it needful and proper to give those papers any other elogium. And it falling out fortunately enough, that the doctor and I (being at some miles distance) did not communicate our designs to one another; as I knew nothing what he had been doing, till I heard it publickly read at *Gresham-College*, when far the greatest part of my experiments were (as is known to more persons than one) already recorded; so I afterwards scrupulously abstained from borrowing the trials mentioned in his papers, to enrich mine. Which forbearance was the more easy to me, because after the first time I heard those papers read, I never desired a copy, nor had a sight of them. By this means it happened, that besides those many titles, which being handled at large in

* This is pointed at in the first page of the following account, where mention is made of an honourable person, &c.

the history, are left untouched in the following tract, even on those occasions, where the learned doctor and I happen to treat of the same subjects, our trials are but very few of them coincident; upon which score the reader will meet with more variety betwixt us, than probably he would have expected to find on such an occasion.

HAVING drawn up this advertisement about the doctor's papers, as supposing them the very same he presented to the Royal Society; upon a sight of the following sheets, (as they were some hours since brought me from the press) the additions I there find, make it appear necessary to say something further to the reader. I must inform him then, that about the middle of this winter, and about the end of *December* 1664; I presented to the Royal Society several books, containing each of them eighteen or nineteen of the twenty-one titles, whereof my history consists; that the Virtuosi might have the opportunity of the cold (which then began to be so strong, as to keep the press from dispatching the rest of the book *) to examine my experiments, and add to them: and one of these being delivered to the doctor, as the likeliest person to make use of it, together with an order to the stationer, to let him have the remaining sheets of the book, as fast as they should from time to time be printed; he had the curiosity, as to enlarge some of the things he had already tried, and brought in himself, (as is intimated in page 711) so to make trial of some particulars, that I had proposed and performed, which either their importance, (as the way of freezing from the bottom upwards, by me suggested, and the weight of bodies frozen and unfrozen) or his opportunity invited him to make choice of; and has been pleased to afford them place among his own experiments †; by which means, though the coincidence of what we deliver will appear to happen more frequently, than the advertisement will make one expect; yet to such readers, as do not prefer variety before certainty, the coincident passages will not, in likelihood, be unacceptable. For, in those cases, where the events of our trials are the same, it is like the truth will be the more confirmed ‡; and in cases where the successes are very differing, the reader will be excited to make farther trials himself, and will be thereby enabled to judge, which trials have been the most carefully made, and the most warily delivered. And, though I think it but a necessary profession for me, to say on this occasion, that I am pretty confident of my having performed my duty, as to the historical part; yet this need not hinder, but that most of the differing successes, we are speaking of, may prove but instances of the truth of what I long since admonished the Reader (in my preface) that there are among the experiments of cold, divers, that are liable to contingencies; so that, as I would not have the papers of this learned man comprehended in what I said of the jejuneness of the writers I had met with, who treat of cold, in a preface written, when I was not sure the following papers would not be made publick; so I hope the reception of these papers of this ingenious person will be such, as may invite him to hasten the publication of those fruits of his learning and industry on another subject, which divers of the Virtuosi do not more expect, than desire, to have communicated to them.

The Art of
Pottery.

* See the publisher's advertisement to the reader.

† Among which I am since informed, that he had tried divers, before he saw my papers.

‡ So one of the chief passages of the *Examen of Antiperistasis* is much confirmed by page 711, following; which contains an account of a trial made by the command of the Royal Society, to whom it was proposed by the Author of the *Examen*, with a request, that they would please to order it to be made.

ACCOUNT of FREEZING,

Made in DECEMBER and JANUARY, 1662.

SINCE the business of freezing is obnoxious to many various contingencies, I must necessarily premise these following circumstances. That these experiments were made in very hard weather, yet with some alternate relaxations, the frost continuing above six weeks. And the place I chose was in stone windows, exposed to the North, and North-east winds, and some upon the ground. The vessels were glass-canes of several bores; earthen and pewter, small pans and porringers; spoons of pewter and silver; glasses of various figures, as phials, cylindrical, round and square; flasks, recipients, bolt-heads, and some conical ones. Most whereof, by the diversity of their figure, their openness or closeness, produce various effects in freezing, as the following observations will shew. The quantity also of the liquor exposed is to be considered; for what will shew a small thin plate of ice in a small parcel of some liquors, will shew none in a greater.

THE method I shall follow in delivering my observations shall be, first, to run over the various liquors or bodies, whether fluid or consistent, simple or compound, &c. used in this work. Secondly, what figures observable in those ices. Thirdly, some effects arising thence. Fourthly, some properties and qualities. Fifthly, some lets or helps both to freezing and thawing. Sixthly, some uses of ice.

IN pursuance of which particulars, I had recourse to those ingenious queries of Mr. *Henshaw*, registered in your *Cimelia*, and then to *Bartholinus*, in his late book *de Nive*, and to my own collected notes from various authors, adding whatsoever trials I thought meet. And in all these I have barely set down matter of fact, neither mentioning the authors, nor their errors, which would have been both nauseous and tedious; nor shall I endeavour to render a reason of the various *Φαινόμενα*, (which cannot be done without a volume) but shall leave that province to an honourable person of this society, who hath had much experience and reflections on this subject. And now to my task.

As to my first head of things used, I shall begin with common water, which I exposed in a triple state, in like quantities, and in open pans, *viz.* first, cold; secondly, boiling hot; thirdly, an equal mixture of both the former. The effect was this; the cold was frozen in one hour, the boiling hot in two hours, and the mixt in an hour and a half; but with this difference, that the cold did freeze first at the top, and sides, and had a large thick crust before there was any shew of ice in the boiling hot; but the mixt and boiling hot began to freeze first at the bottom of the vessels, and when the top was cold, then it froze there also, leaving betwixt the bottom and top of the vessel a cavity for the water, which in time was wholly converted to ice. The same succeeded most manifestly on these waters poured on a smooth table, where the cold water was presently frozen, before the boiling hot water could become cold at the bottom.

WATER exhausted of air in Mr. *Boyle's* engine was frozen almost as soon as a like quantity exposed in an open pan; the ice whereof appeared white, and to consist purely of bubbles. The glass used was a four-ounce round phial, and a small tube one foot long half filled with water.

FAIR water, wherein arsenick had been infused eight months, congealed much sooner than a like quantity of water, into a very white ice.

SOLUTIONS of all the sorts of vitriols freezed sooner in pans and tubes, than water, or any solution of the other salts by much, though that of allum came very little short of it. The ice kept both colour and taste upon the least touch of the tongue, in all of them.

A SOLUTION of allum did freeze into an ice whiter than milk, and stuck so close to the sides of the pan, that it could hardly be separated from it: this was the firmest ice offered to me in all my trials; next to which, in both these qualities, were the vitriols, especially the Roman.

SANDEVER quickly freezeth, frit sooner than it, and kelp than them both; all of them into lumps very white, and consequently not diaphanous.

SAL ARMONIAC shewed some variety in point of time; for in the same pan, quantity, and place with the other salted waters, it would, for the most part, freeze long after the former, though once it did freeze before them.

COMMON salt two drachms dissolved in four ounces of common water (for that proportion I observed in all my solutions) did, in 30 hours space, in the hardest season, turn to pretty hard and white ice; whereas the former solutions became so in two or three hours at the most.

A BEER-GLASS was filled with stinking sea water full of salt, which within 26 hours acquired at the top a plate of ice of the thickness of half a crown-piece, with few bubbles in it. This tasted salt and stinking as before, but being dissolved at the fire, or thawed of itself, the stinking taste was gone, but the saltish continued. The residue in the glass within four days (the season continuing) and plates taken off (once in twenty-four hours) was frozen throughout, but that at the bottom of the glass seemed to have a much brisker taste than that at the top, neither was it so firm and friable as that. I tried another beer-glass with the same water, which froze most part of it, but the season continued not so constantly sharp so long together, as in the former experiment, and therefore I could conclude nothing therefrom. But in small broad earthen pans set in ice, in 36 hours the same water became ice throughout, and with the addition of a parcel of ice or snow much sooner.

SOME water is impregnated with as much bay-salt, some with as much salt-petre, some with as much sal armoniac as the water was capable to receive, and neither of these did congeal with the highest degree of cold, continued six days together.

A SOLUTION of salt of tartar soon converted into ice, but in much longer time than common water. I observed, that it began to freeze in a tube at the top, bottom, and sides first, leaving the liquor in the middle unfrozen; whereas other solutions and liquors congealed uniformly, by descending, or ascending, or both at the same time, from side to side through the middle. Of this I made but one trial.

SALT-PETRE required 28 hours in a very cold season, and in that time became in the open pan a most pure white ice perfectly like sal prunellæ, which an apothecary mistook it for. This ice thrown into the fire (after the aqueous humidity was evaporated) did sparkle as that salt useth to do. A strong lixivium made hereof with an addition of copperas or allum singly, or mixt, set in snow and salt, or snow alone, was frozen in one night.

SAL GEM alone of all the salts, though snow and ice were mixed with it in great proportion, and though the pan was set in salt and snow, could not all that time be brought

brought to congelation; an odd experiment. Phlegm of vitriol did freeze sooner than the solutions before-mentioned.

OIL of vitriol begins congelation (or coagulation rather) near as soon as fair water. A pretty large tube was filled $\frac{3}{4}$ full with this oil, and about $\frac{1}{4}$ thereof was frozen, the rest remaining at the bottom uncongealed. This tube was broken in the presence, and by the command of this honourable society, the coagulated part whereof was tasted by many then present, and concluded by all those, that it was a strong vitriolate taste. This coagulated part was of a paler colour than the other, and both these mixed and poured into a phial-glass heated it so hot, that none there could hold it. This coagulated part kept so in the air a week after all my other liquors had been thawed, and would, in probability, have continued so much longer, had not the glass been broken. I exposed another lesser tube with the same oil, which became frozen throughout, and required very much relaxation in the air to return its former fluidity.

I HAD set a mark on these tubes (as on all the rest, to observe their several risings) and the oil of vitriol, when coagulated, sunk more than half an inch below it, and being dissolved at the fire, returned to its first station, as you also saw. And this *Φαινόμενον* is peculiar to this oil alone, all other liquors rising higher than the mark.

I NOW come to my stronger liquors of beer, ale, and wines.

I EXPOSED at the same time a flask of small beer, and another of strong ale; the former whereof was frozen throughout in 38 hours, but three pints of the ale continued unfrozen after six days continuance of very hard weather. And the air then disposed to thawing, I broke the flask, and with the unfrozen liquor made an excellent morning's draught at four in the morning. This ale in colour, strength and quickness seemed to me and the other three tasters that sate up with me, much better than when it was first put into the flask, and by comparing it with some other in the house of the same barrel, we plainly found the said difference. After this I took the icy part of the ale, and thawed it at a fire, which was in all a pint of liquor (though the flaggon contained three pints of liquor, was filled with the ice) was very pale, and of a quick and alish taste, very much resembling that drink, which the brewers call *Blue John*. This ice was not so firm as that of water, but fuller of bubbles.

I ASSAYED the same a second time, but could not, by reason of the changeableness of the weather, attain so great a thickness of ice as in the former. And in this also I found the same changes as before.

A BEER-GLASS of *Hull*-ale in twenty-four hours contracted a crust of ice as thick as an half-crown, and proceeding, as in sea-salt water, the *Φαινόμενα* were the same, all the laminæ taken off appeared of the same colour and taste, and the lowest ice was the most tender. Another glass of the same ale exposed did not freeze throughout (no crust being taken off) in five days, when my own ale did in a like glass, both being set out together. Now the taste and colour appeared the same, or at least had no sensible difference, when they had been thawed of themselves, and when first exposed. *Hull*-ale hath a brackish taste.

CLARET very strong exposed in a spoon, in 35 hours hard freezing became an ice all of it; it was soft, kept its former colour and taste, soon discovering to the tongue of one who knew not whence it was, its nature, quality, and kind.

CANARY at the same time in a spoon exposed, in 38 hours acquired on its surface an exceeding thin plate of ice, as thin as the finest paper, and proceeded no farther in four days following.

NEITHER

NEITHER claret nor canary would shew the least sign of congelation in tubes, much less in bottles.

Two ounces of the best spirit of wine exposed in an earthen pan did all evaporate in less than twelve hours, but the same quantity of brandy left near a spoonful of insipid ice without any taste of the spirit, which cast into the fire flamed not at all. I could discern no bubbles in this phlegmatick ice, but having interposed it betwixt mine eye and a candle, it manifested many bubbles by its shadows. Query, whether this may not turn to profit in colder countries in rectifying spirits of wine?

WE now come to consistent bodies, and shall begin with animals, and their parts.

Two eyes, the one of an ox, the other of a sheep, in one night were both totally frozen; the three humours were very hard, not separable one from another, neither of them diaphanous, as naturally they are; and the crystalline was as white as that of a whiting boiled. The tunicles, fat, and muscles were also frozen, as appeared by their stiffness, and by putting them into cold water. The ice of the watrish and glassy humours seemed to be made of flakes.

A PINT of sheep's blood did freeze at the top, and all the sides of the dish, wherein it was put, and was nothing else but the serum of the blood. This ice being separated from the blood, and thawed at the fire, and then again exposed, congealed into a seeming membranous substance, and was taken for such by some that saw it, and so continued in a warm season, and appeared in all respects a membrane. This also was seen and registered in the journal. The blood remaining gave me no signs, that frost had taken it.

I DISSECTED a dog and a cat, having lain dead in the open air, and found their entrails, nay, the very heart stiff, and some little ice in the ventricles of their hearts, and their *vena cava*.

MILK soon freezeth into moist white flakes of ice, retaining the proper taste of milk; these flakes are soft, and manifest not many bubbles.

SEVERAL eggs were exposed, and both yolk and white in one night were hard frozen. They require a longer time to freeze than apples do. The best way to thaw them both, is to lay them on *Newcastle*-coal, or in a deep cellar. Whether eggs once frozen will produce chickens or no, I cannot say, but have been told by good house-wives they will. Some affirm, that eggs and apples put into water, the ice will be thawed within them, and the ice appear on the shell and skin. It is true, if you hold either of them near the surface of the water, they will soon gather a very thick crust upon their outsides; but if you then break the one, or cut the other, you shall see them full of ice, and the eggs then poached will taste very tough. So that this ice seems to be gathered from without, and not come from within. And besides if it did so, they must needs lose their weight, the contrary whereof will anon appear. But for the more surety, I proceeded to this farther experiment. I immersed in my cistern an egg, and an apple, two foot deep into water, and there suspended them with strings tied about them, to keep them from sinking for the space of twenty-four hours, and then took them out, and opened them. I could never observe in that time, though I often looked at them, any ice on their outsides, and the one being broken, and the other cut, were found both of them full within of ice.

THE next order shall be vegetables, and of them a few instances, especially those which are of a biting or sour taste. Now for the first, I employed the roots of horseradish and onions, (for other edible roots and plants every one knows will freeze) which shewed the frost had taken them by their taste, and ice was found betwixt each
of

of the skins of the onions, retaining the taste of the root; yet I have observed beer, wherein horse-radish and garden-scurvigrass have been infused, will not freeze so soon as other stronger beer without them.

ORANGES and lemons frozen have a tough and hard rind, their icy juices lose much of their genuine taste; they were both frozen hard in 26 hours, or a little more, having a thick rind. They, as other fruits, when thawed, soon become rotten, and therefore the fruiterers keep them under-ground in low cellars, and cover them with straw, as they do their apples.

WHICH did, exposed in one night, freeze throughout. If you cut one of them through the middle, it will have on both the plains a most pure thin ice, hardly discernible by the eye, but easily by the touch, or by scraping it off with a knife. The cores of these apples soon turn brown, and begin their corruption there.

OIL exposed did acquire the consistency of butter melted, and cooled again; but in caves and cellars I could never see it more than candy.

STRONG white-wine vinegar did all soon freeze in a tube, and without any apparent bubbles.

AND to conclude, without mentioning nuts, bread, butter, cheese, soap, and many other things, which came under my trial, it is most certain, that whatsoever hath any waterish humidity in it, is capable of congelation: what are not, you have in the next paragraph.

HAVING now done with what will freeze, I shall briefly recount some things, whereon the cold hath no such effect.

WE mentioned before spirit of wine: add to it such strong waters as are made of it, viz. aqua Mariæ, cœlestis, &c. and canary wines in larger vessels. Secondly, the strong lees of soap-boilers, and others made of other salts, to which refer the spirits extracted from salt; vitriol, salt-petre, aqua fortis, and spirit of sulphur, which last precipitated to the bottom of the tube a small quantity of powder, very like in colour to *sulphur vivum*, which being separated from the spirit (for nothing of that evaporated) cracked between my teeth, and tasted like brimstone, and being put into water, made it as white as lac sulphuris doth, but it would not flame, perhaps because too much of its strong acid spirit was mixed with it. Spirit of foot afforded also a precipitation or sediment (the spirit not congealing) at the bottom of the tube of a yellowish colour, but much bitterer than the spirit itself, and inflammable also.

BUT here it is to be observed, that the said spirits, that would not freeze alone, yet with the mixture of about 12 parts of water, or less of ice, or snow, did freeze throughout; except the spirits of salt, of nitre, and aqua fortis, which would not freeze with those quantities of water, ice, and snow. I intended to have tried them with a greater quantity of the said ingredients, but the weather failed me.

WHETHER the salt-water freeze in the sea, I cannot experimentally determine; but I shall add what was told me by one, that said he had dissolved ice in the northern seas, and found it very salt.

THE next proposed was the figure of liquors frozen; wherein I shall observe in general, that most of the liquors differed from one another in their figures, and being permitted to freeze, and thaw often, they still returned to the same figure, most whereof were branched. Allum appeared in lumps; salt-petre, tartar, milk, ale, wine, and sal armoniac in plates; and other liquors mentioned to freeze into a very soft ice, seeming to be made up of small globuli adhering each to other. Fair water, kelp, and the frits resembled an oaken leaf, the leafy parts being taken away, and the fibres only remaining, the interstitia being filled up with smoother ice. The middle rib

(if

(if I may so say) as in plants was much bigger than the lateral ones, all which seemed but different *stiria*, whose points extended towards the outside of the vessel containing the water, and made acute angles with the middle rib towards the lesser end of the said leaf.

CONCERNING the figures of frozen urine I shall say nothing, the accurate description of curious Mr. *Hook* having so fully and truly performed that part of my task.

Now as to the famous experiment of *Quercetan*, and affirmed by many other chymists, I made experiments in these following vegetables; rosemary, rue, scurvi-grass, mints, and plantane, wherein I thus proceeded: I mixed with $\frac{1}{2}$ a pint of their distilled waters $\frac{1}{2}$ or $\frac{1}{4}$ of an ounce of their own salts; the rosemary and rue were calcined, and their salts extracted with their own waters, and then were added to their salts their own distilled waters in the above mentioned proportions. The glasses, wherein the rue and plantane were put, being sealed with *Hermes's* seal, and the other glasses left open, the effect was, that neither of them shewed the least resemblance of the plants, from which they were extracted, neither figure, nor shew of roots, stalks, branches, nor leaves, (but only a lump or heap of small globuli) much less of flower or seed. Besides the kelp frozen hath many fibres, which is made the most of it of *alga marina*, whose leaf is long and smooth without fibres in it. This one thing I cannot pretermitt, that the scented waters seemed upon their thawing to have acquired, and advanced much in their scents, and especially the rosemary, whose salt hath no smell, and its water but little; yet thawed, they smelt as strong almost as fresh leaves rubbed and smelt to.

A LARGE recipient was filled with water, which being frozen throughout, and the upper crust of the ice broken, there appeared in the middle of it a multitude of thin *laminae* of ice, some more, some less wide, from which proceeded *stiria*, or teeth pointing inwards, and set at pretty equal distances, so that the *laminae* and *stiria* resembled very much so many combs placed in no order, some lying directly, others obliquely, none transversely, having intervals betwixt each of them; betwixt some of them I could put my finger without breaking the points of the *stiria*: these combs were placed round about a cavity in the middle of the receiver sufficient to receive two of my fingers.

IN a flask filled competently with water, when it was frozen, there appeared throughout the ice infinite silver-coloured bubbles, very like unto tailed hail-shot of several sizes, the largest about $\frac{1}{4}$ of an inch long, where thickest, of the bigness of a great pin's-head, others much less in all dimensions. The points of them all looked outwards, and the bigger part inwards towards the centre, where also were the largest. For there they would easily admit a little pin into all their cavity, without the least resistance. The figures of them were pretty regular: first, a small thread, and then a head as big as a shot, and thence gradually ended in a point. Some of these were streight, most a little crooked. There was a cavity in the centre of this ice filled with unfrozen water, from which I could find multitudes of cavities of bubbles, not fully formed. And in the more solid parts of the ice cut, you may discern them by a black spot, where the hole enters into the cavity. All the same phenomena appeared in a second trial, but that the bubbles were shorter and larger, and not so sharp pointed. The like I also observed in a conical glass sealed up.

THE next thing to be treated of, is the effects of freezing, viz. the expansion of liquors frozen, and consequently thereunto the breaking of bodies, wherein they are inclosed. All the liquors tried did sensibly in glass tubes rise beyond my mark, before the liquors could be discerned to freeze, and after rose somewhat higher with freezing. The height of the rising I shall here set of a few experiments, instead of

many made (having troubled your patience too long in the former paragraphs) in several processes. Vinegar and urine rose about half an inch, and lees made with salts of rosemary, kelp, the frits, about $\frac{1}{4}$ of an inch. Solutions of alum and copperas somewhat less, and in general the saline liquors less than water, which rose a full inch, and small beer in a very narrow tube four inches; but water in the small capillary tubes could not be perceived, either to expand it self, and certainly not to freeze at all. Oil of vitriol alone (as hath been said) sinks below the mark. Hot water put into a tube first sinketh till it is cold, and then riseth before it freeze.

OPEN-mouthed glasses, such as beer-glasses, &c. filled with water up to the brim, when frozen, the ice will manifestly rise above the superficies, and make a solid triangle there. But narrow-necked glasses more plainly shew this rising. In a flask filled with water four inches below the mouth, the ice rose above the mouth, and hung two inches without it. And once in a bolt-head the ice rose five inches above the water-mark. And here I shall briefly add two things; first, that if glasses be filled about $\frac{2}{3}$ full, they seldom break; but if more, they will for the most part break. Secondly, that round-figured or spherical glasses for the most part break in an uniform manner. I filled a bolt-head full to the neck, and stopped it at the top, which was twelve inches distant from the body, with a piece of melted candle. The ice rose above three inches in the neck, and the glass broke in the thinnest part of the body, from the point of breaking, as from a pole, the cracks run as so many meridians, but unequally distant each from other, and consequently concurred not in an opposite pole on the other side; besides there was great difference in the length of those cracks, none whereof went round the glass. In a flask thus crack'd in many places, the cracks were very irregular in all the places; for some of them ran from their centers upwards, others downwards, some somewhat parallel, but most obliquely, and few of them were considerably straight. Glass-bottles, and especially stone-jugs, keep very little, and the last no method in their breaking: the same also befalls square glasses: woods follow their grain, and metals no order at all.

AND now I come to some remarks proceeding (as I said) from this expansion, *viz.* the breaking of the vessels, or force of freezing, wherein also you may take notice of that quality of cold, mentioned by the poet, *penetrabile frigus*, piercing where light comes not.

Two oval boxes, the one of box, the other of maple (both firm woods) containing each above two ounces of water, were filled full, and with screws closed very fast: both these boxes were rended from the bottom to the top in one night, with gaps big enough to receive a barley-corn into them: these woods stretch but little, and therefore break more surely, and with larger rents than softer woods will do.

SECONDLY, a pepper-box of latten made of iron, covered with tin, had the neck broken off, and holes made in the top near the neck; and the bottom, where it was soldered, was so dissevered, that water would easily run out there.

LEADEN pipes laid above ground were broken in many places. One I saw twenty yards long broken in seven places, and another in my cellar six yards long, broken in two places. I saw likewise in many places of this city leaden pipes, above a foot deep under ground, broken in several parts.

Cocks of cisterns, and other brass cocks, and also the barrels in pumps made of brass or lead, usually break with the frost.

I EXPOSED a copper box of a pear fashion, which did bear three several freezings, by reason of the great extensibility of that metal; but at the fourth essay it cracked all along one side of it, almost to the screw.

NEXT I tried a cylindrical silver ink-horn; but that did bear five trials, and therein I could perceive neither crack, nor dilatation of its superficies. I intended to have tried it in a small bottle, but the weather failed me. I exposed also a round silver ball of the bigness of a large nut; the silver became very sensibly extended to a larger superficies, but did not suffer any solution of its continuity.

TOBACCO-PIPES, and all earthen-ware, taking any frost in their drying, (before they are burnt) become very brittle, and being put into a strong fire, will certainly break into many pieces. Tiles of houses, and hard stones in buildings, scale and break off upon thawing; and thence it is, that the northern sides of stones-buildings first decay, and moulder away, as it is most manifest in antient magnificent structures.

ALABASTER and marble having any chinks in them frequently break with frost; and the statuary tell me, they never saw any solid marble break: as for flints, paving-stones, precious stones, and such as will receive a polish, the bitumens, as amber, kennel-coal, &c. I could never see any effect on them.

THE next effect shall be that of adhesion, concerning which take the following experiments.

A SMOOTH piece of ice was laid on a smooth table, and common salt thrown upon it; the effect was, that the ice stuck so firmly to it, that it could not be severed from the table, without breaking the ice into many small pieces: and it will continue in this close cohesion, till the salt hath corroded through the ice to the very table, (making many holes in the ice) and hath melted it to the very bottom. But if you lay salt first upon it, then the ice sticketh not, but thaweth. These following salts applied (as before common salt was) cause adhesion to the table, but not so firm as it, *viz.* kelp, sandever, sal Indus, gem. prunellæ, and armoniac, and pot-ashes, but not alum, or vitriol.

THE next experiment of adhesion was this; I held a nail betwixt my lips in the open air a very little space, which stuck so firmly to them, that I could not pull it thence without difficulty and pain.

ANOTHER effect is concentration of spirits and colours. Concerning the former, you have already as much as I know, especially in the paragraph of freezing beer and ale. Concerning the latter, take these following trials. Cochineal was boiled in water to a very high tincture, and frozen: and to twice four ounces of this decoction was added in one glass a little spoonful of spirit of wine, and in another as much sea-salt-water: all these were frozen throughout, and every part of this ice seemed to me of an equal colour, though the edges, as thinner and nearer the light, appeared of a brighter colour (as they do unfrozen) but the glasses being broken, shewed no discernable difference in any of them, neither as to colour nor taste. The like trials were made with madder weed and indico, and the success was the same.

SECONDLY, I exposed a pint pottinger full of the decoction of foot, which (the air relaxing) did only freeze an inch thick: this continued above a week consistent (in a thawing season) and very solid. Some, that saw it, judged it to be brown sugar-candy, the taste whereof was near, if not altogether as strong as the uncongealed liquor remaining at the bottom. And in another trial, when the whole was frozen, no concentration was seen. But though it was not my hap to find this effect, my trials having been made in phials, square, cylindrical or round, yet Mr. Hook, a worthy fellow of this society, happily lighted on it, as you may perceive by his relation, and schemes of his glasses hereunto annexed.

SOME affirm, as an effect of freezing, an addition of weight made in the bodies frozen; but this affirmation answers not my trials. For in four eggs, and four apples

fully frozen, I found the weight of them the same, when frozen, and thawed, as they had before they were exposed; each of the eggs and apples being weighed in this triple state both severally and jointly: with the particular weights I shall not trouble you. Besides, that freezing adds no weight, it is apparent in sealed glasses, from whence nothing can expire, and by exact ponderation of them, I could not perceive any the least difference in weight in the said triple state. This I tried several times with as much exactness as possibly I could, and still found the same event.

ANOTHER property of freezing is to render many bodies more friable and brittle; as most woods, as also iron and steel, as every one knoweth, that hath used cross-bows in frosty seasons, and so likewise the bones of animals; and it is commonly observed by surgeons, that more men break their legs and arms in such seasons, than at any other time of the year, especially such, who have been tainted with the *Lues Venerea*, as *Hildanus* somewhere notes.

I SHALL NOW conclude the effects of freezing, by ranging them into good and bad. The good, are the long preserving bodies most subject to putrefaction; healthiness, and confirming the tone of all animals; and thickening the hairs and furs of such as have them, fattening some. Besides, it exceedingly clears the air, and other bodies, as it is manifest by the stinking sea salt-water before-mentioned, as also by this that follows: namely, I took six of the most musty stone-bottles I could procure, and competently filled them with water, which, after freezing and thawing again, became as sweet as ever they were before.

BAD effects, are the killing and destroying animals and vegetables by congealing and stopping their vital and nourishing juices, rendering them totally immoveable. It is observable, that in *Greenland*, and *Nova Zembla*, nothing but grass grows; as also what was told me by Dr. *Collins*, the present physician of the emperor of *Russia*, that no thorny plant or thistles grow in that country. And this present year most of the rosemary and sage about *London* was wholly destroyed, besides most of the more tender plants.

MY fourth proposal was the properties and qualities of ice, some whereof my task ingageth me to enumerate only; such as are its slipperiness, smoothness, hardness, whereby, and by its bulk and motion, it breaks down bridges, &c. its firmness and strength to bear carriages, and burdens; its diaphaneity, which is much less than the liquor, of which it is made. For I could never discern any object, though but confusedly, a foot beyond the clearest piece of ice, by reason of the many bubbles and luminous parts within it. Which bubbles shew only shadows, but the ice itself interposed betwixt your eye and a candle appears in many round circles, from which proceed many rays of light, four or five, or more, in the form of a star of about $\frac{1}{4}$ of an inch in diameter, which so glaze your eyes, you can scarcely see any thing but bright light and shadow.

As for its penetration and thickness something hath been said above; to which I shall add, that I have seen the *Thames* ice of the thickness of eight inches, or more, near the middle of the river, and on the sides much more. And in garden-walks the earth frozen near two foot deep; whereas on the other sides of the same walks, on a richer mould, the frost did not reach much above one foot and $\frac{1}{2}$, and pipes of lead have been broken above a foot under the surface of the ground. I shall not mention the huge mountains of ice found in the most northerly seas, but proceed to its weight.

It is generally known, that ice swims upon the water. But I have seen snow-balls, moistened only with water, and then compressed with a strong force, and afterwards frozen, to sink: besides, the congealed oil of vitriol descends in water, and common

ice is frequently observed under water; whether the solutions of salts frozen will sink, was by me forgotten to observe, and whether coagulated oil will sink in unfrozen, as *Bartholine* affirms. Some affirm, that snow-balls hard pressed, without addition of water, will sink; but experience teacheth me the contrary.

As for its tactile qualities, every one knows it is colder than water, which you may increase by adding salt unto it, or rather snow.

SMELL it hath none, but it binds up that quality in all; but most spirituous bodies, which it also in some degrees refracts in them.

LASTLY, ice yields both reflection and refraction, whereof I shall speak, when I come to its uses.

My fifth head was lets and helps in freezing, which I shall briefly dispatch. Those besides the North and North-east winds, the absence of the sun, and the highest parts of houses or mountains, are the mixture of snow and salt (than which there is nothing more painfully and insufferably cold to my feeling) as is apparent by the trick of freezing with snow and salt by the fire-side, as also by the ingenious way of making cups of ice, invented by an incomparable person.

ADD hereunto, that water falling or thrown upon ice or snow soon becomes congealed. A mixture also of ice beaten into powder, and mixed with common sea-salt (which is best) or with kelp, allum, vitriol, or nitre. And here note, that vessels filled with water, and set upon these mixtures, begin their freezing at the bottom of the liquor, and consequently are not so subject to be broken, as those are, which are not set in these mixtures, and that the water riseth higher with, than without them. I find also, that oil of vitriol alone, mixed with snow or ice, have the same effect, though not so powerful.

ONE affirms, that salt-petre dissolved in water, and put into a bolt-head, and long agitated, not only cools the hand exceedingly (which is very true) but also converts it to ice, yea, in the very summer months, which answereth not my trial, though kept a whole hour in that agitation in the hardest season.

THIS following experiment also I add, proposed to me.

I FILLED a bolt-head, containing a quart of water, and set in an iron pan, surrounding it on every side with snow, which covered also part of the neck; and then set the kettle over the fire, and took now and then the bolt-head from the fire, whilst the snow was thawing, but not the least sign of freezing appeared in the water put into the bolt-head.

As for the helps of thawing, take this experiment. I set in the same cellar three pans full of ice, one on *Newcastle* coal, a second on sand, a third on the earthen floor; they thawed in the same order they are mentioned, which was thrice repeated, and once that placed on the coal did thaw, when the other continued their ice. Sealed glasses seem neither to promote or hinder this act of freezing. The same success I had with eggs and apples in my cellar.

THE last thing I shall speak to, is the use of ice. You may therewith make a siphon, being fashioned and applied, as usually siphons are; and this will happen, whether you make it one continued piece of ice, or two contiguous ones; for in both the water will run exceeding fast, and this siphon soon empties all the water out.

A SECOND use is for refraction, whereof *Mr. Hook* hath given you already a learned demonstration. And I having formed some ice into various figures, like most of those mentioned by the dioptrick writers, the *Φαίνόμενα* were the very same as in the like figured glasses; but how *Descartes* made dioptrick glasses of it, I know not, especially to make use of them. And lastly, you may make a speculum of it, especially if a
piece:

piece of blacked paper be placed behind it, and if you hold a candle at a convenient distance, there will appear very many speculums to your eye, according to the number of the bubbles contained in the ice. But I could not observe any heat proceed from ice, though cut in the true figure for burning-glasses, and exposed in naked ice; but frozen in spherical glasses it will heat a little.

I SHALL here subjoin some propositions of the learned *Bartholinus*, taken from his book *De Nive*, being near to the former argument, who affirms,

1. THAT the more subtil distilled spirits gain a clear splendor and elegancy from snow placed about them.

2. THAT the rays from snow newly fallen glitter, and excel in a kind of splendor, wherewith the eyes are dazzled. 'Both these are true, and have but one common cause, viz. the multitude of reflections caused by the infinite globuli, whereof every flake of snow consists.'

3. THAT he saw cabbage growing in his garden, putrify on that part, which was above the snow. 'It is certain, that frost alone, with or without snow, hath this effect on cabbage, being of the tribe of succulent plants; and I observed, that in the year 1644, our great house-leek, or American aloes (usually hung up in houses) kept in an upper room, was totally destroyed by the cold. And that apples will rot, I have said before, and housewives, to prevent the rotting of onions, commonly hang them up in their kitchens, or keep them in their ovens, or some close place. And this present year 1662, I saw at Mr. Box's, the eminent druggist's house, abundance of squills or sea-onions quite rotten: they were laid in an open, but close garret.'

4. WHEN snow melts by the sun's heat, copious vapours from the earth clouded the sun. 'He should rather have said, vapours from the melted snow; and 'tis no wonder, that vapours cloud the sun.'

5. SNOW melts and falls off from ivy. 'I have observed all the sorts of ivies, and evergreens with us, and some biting plants too, but find in them all the contrary to what is here asserted. Nay, no difference hath been observed even in hoar-frosts, which fall equally, and continue on all sorts of plants.'

6. He excludes not a small portion of earth from snow, though pure, which, saith he, is manifest from distillation. 'This experiment I have found true by evaporation, which is tantamount to distillation; and indeed all melted snow leaves an earthy and foul settling behind it.'

7. VISCOSITY with softness is greater in new than in old snow, and therefore it is brought into a mass. 'Viscosity in it I understand not; its softness indeed is manifest too, by the tracks of beasts, which appear more fair, the snow not rising on the sides of the impression made by their feet (as it doth in old) but retains their perfect character.'

8. WATER-CRESSES and scurvigrafs grow under the snow in gardens. 'I apprehend not, that any plant whatsoever grows at all in hard seasons; my meaning is, that no plant acquires any greater bulk of quantity, but keeps at a stand only; and this countrymen affirm of grafs and corn, and gardeners of other plants. It is true many plants will upon thawing shew a finer verdure, and if warm weather presently follow, all vegetables will thrive exceedingly. For how they should thus grow, when their nourishing liquor is congealed, and consequently become immoveable, I understand not.'

9. AIR is included in snow; 'which this way of mine to make snow fully convinceth. I took the whites of eggs, and beat them in the open air with a spoon, into

into a frothy consistence, as women do to make their snow-poffets, and then taking a little of this substance, and laying it on a trenchard, it soon became plain flakes of snow, so that none, that saw them, could judge otherwise. Another accidental experiment proves the same; for having put water into a tube, and having long and strongly agitated it, there arose many bubbles at the top, which soon freezing (my agitation ceasing) became perfect snow. And now having here set down the way of counterfeiting, at least, if not of making snow, I will add, how a pruina or hoar-frost also may be imitated. 'I took a pail filled with warm water, and hung over it hair, moss, and a piece of rosemary: now the atomical vapours rising from the water, fixing themselves on the moss, hair, and rosemary, became on them a perfect hoar-frost. The like is daily seen on the beards and hairs of men and horses, travelling in cold winter nights or mornings, proceeding from their breaths, steams of their bodies, or moist atoms of the air. I tried also to make hail with drops of water, but could not hit on it, for they would never become white. Whence it is manifest, that hail is not drops of rain, suffering glaciation in the falling, as the received opinion of philosophers asserts.'

10. SNOW abounds with fat. 'This I understand not.'

11. SNOW with ice swims on water. 'This is a clear consequence from the seventh assertion.'

12. SNOW-WATER boils meat sooner, and makes the flesh whiter. 'I tried this in flesh and fish, but could find no manifest difference, either to their sooner boiling or whiteness.'

13. SNOW newly fallen hath no taste, but lying long on the ground, or frozen, somewhat bites the tongue. 'My taste was not so acute, as to distinguish the biting of one from the other: It is true indeed, that snow frozen doth more affect the tongue with its coldness, than snow alone.'

14. WORMS are sometimes found in snow. 'This neither my own observation, nor relation from others can make out.'

15. FROM snow, by a peculiar art, a salt of wonderful strength is drawn. 'He saith not this of his own observation, nor teacheth the way to extract it.'

16. AFTER much snow plenty of nuts. 'This frequently suits with the country-man's observation, but many times fails; such years also commonly produce plenty of wheat, other seasons concurring.'

I SHALL here also insert two remarks out of the same authors concerning freezing. The one is, that the great duke of *Tuscany* distilled spirit from wine, only by putting snow upon the alembick, without help of fire. The second, that the duke of *Mantua* had a powder, which soon congealed water into ice, even in the summer.

AND to conclude, take these general observations made by the command of the Royal Society, with weather-glasses framed after the *Italian* mode, and filled in part with tinged spirit of wine. Which I shall deliver briefly, and in gross, and not each day's alteration apart. I took then two of the said glasses of equal dimensions, as near as might be, and filled them with the same spirit of wine; one of them I placed in my study-window, standing north-west, the other in Mr. *Pullyn's* ware-house under St. Paul's church, and chose there a small recess or room, which was most remote from the entrance, and the warmest in the whole ware-house. Both the glasses were settled in their stations the 15th of *October* 1662, the spirit in both having the altitude of three inches just. When the glass in my study was depressed by the cold an inch, I went and observed that in the ware-house to have received no manifest change in its station. And at a second visit the spirit was depressed $\frac{1}{2}$ of an inch below, when that

above

above ground was depressed near two inches. And during the long continuance of all that hard winter, it never descended above $\frac{1}{4}$ of an inch, and never was higher there than three inches and $\frac{1}{4}$ in a mild season in *April* following, by which time the papers fixed to the glass, and whereon were fixed the degrees, were quite rotten, and the characters scarcely legible. And at the same time, that in my study was raised to four inches $\frac{1}{4}$. By which it appears, that the said ware-house was in the coldest season as warm as in a mild *March*, for at that station the glass in my study stood commonly betwixt two inches and 2 and $\frac{1}{2}$. And so indeed this place appeared to one, that went into it at the coldest season. And to this purpose I several times sent in at night my hardest frozen liquors, which were constantly thawed in the morning, though it froze exceeding hard above ground.

THE glass in my study, after two days hard freezing, was sunk below my marks into the very ball; so that I could make no further observations concerning the cold above ground.

FROM the former observations, that popular error is manifestly refuted, *viz.* that cellars and subterraneous places are hotter in the winter than in the summer; which, though they appear so to us, because they warm us in the winter, and cool us in the summer, yet they are not so in themselves: for it appears by the former experiment, that in the coldest season the spirit was depressed to two inches and $\frac{1}{4}$, and rose in *April* to $3\frac{1}{2}$; and no doubt would have risen about $\frac{1}{4}$ of an inch higher, had it continued there, till the hottest season of the year.

ONE thing more I observed, *viz.* that the tinged spirit of wine had in this subterraneous vault totally lost its colour, whereas that in my study (two years after) still retains its former tincture.

SINCE the printing of the foregoing papers, *viz.* 1664, (there being no frosts in England 1663) I made these following experiments.

FINDING the 3d of *January* the season disposed to freezing, I exposed a pint bottle of claret, and a glass-cane filled with canary, a solution of sal gem, train oil, and the oil of *fructus musæ*; and on the fourth of the same month, the night being the coldest and sharpest that I ever felt, (which all I spake with the next day confirmed) the wind then blowing hard at south-west, I found in the morning all the liquors frozen, except the sal gem exposed in an earthen pan, which shewed at the bottom of the dish some seemingly crystallized salt; the oil of the same fruit became very friable, and of a milky white colour, but the train-oil only lost its fluidity, and became of the consistence of soft grease. And the same night a bottle of the Rhenish wine, called *Back-rag*, and another of lusty white-wine, standing in a room a story high, exposed to the said wind, had most of the wine frozen in them; the ices whereof being taken out, tasted somewhat weaker than the wine itself. All the same things happened the sixth night of the same month. It is to be observed, that the pint of claret, and the sack in the tube, were both frozen throughout these two nights, and after their double freezing and thawing, they lost nothing of their spirit, colour, and taste; nay, the claret being a strong *Burgundy* wine, though it often suffered glaciation and thawing for three weeks together, yet in all that time suffered no manifest alteration, but appeared the same to sense, as when it was exposed, in colour, taste, and strength.

As to the concentration of coloured liquors, Mr. *Hook* shewed me an oval glass, having at one end a narrow cane above an inch long, almost filled with water, tinged with cochineal, frozen; throughout, the ice round about, towards the sides of the glass, shewed wholly colourless, but that in the midst was of an exceeding high dye, but the ice, that was raised to the neck of the glass, was lightly tinged with a scarlet

scarlet hue. Hereupon having some flasks by me, I put into one a strong decoction of cochineal, and into another a like decoction of foot, which being exposed to the air, and incompassed in a vessel with snow and salt, they did freeze to the thickness of an inch or more; and the air then beginning to relax, I broke the flasks, and the dissolved ice yielded a water totally colourless. I made also an experiment with a very strong decoction of gentian roots, which being exposed in a four-ounce phial, the ice thereof had a far deeper colour, and bitterer taste in the middle, and towards the bottom, than towards the outsidés of it.

AND whereas *Barclay* relates, that King *James* being in *Denmark* to fetch his Queen thence, in the winter season had his nose and ears in danger of gangreening; which being timely perceived by some of the King of *Denmark's* nobility, they caused the parts to be rubbed with snow, and so the danger was avoided; the same travellers affirm, that in the northern parts, where men become stiff with cold, and almost frozen to death, that they rub the frozen parts with snow, or else cast the whole body into water, by which means the whole body is crufted over with ice, as eggs and apples are, as if the freezing atoms did pass from the body frozen into the water or snow; and this way of curing gangreens from cold, *Sennertus* doth prescribe. To make some experiment hereof, I exposed flesh and fish, and found, that by immersing them into water, they soon became more limber and flexible, and more easily yielding to the knife, and compassed with a crust of ice of the thickness of about half a crown, manifest tokens of their thawing; and being cut, they discovered nothing of ice in them. This, for more certainty, I often reiterated, as also in eggs and apples, above a dozen times, and never failed of unthawing them by this way. It is to be noted, if you immerse the flesh, fish, eggs, or apples deep into the water, no ice will appear on their outsidés, but only when you hold them near the surface of the water.

As to the Persian experiment mentioned by *Olearius*, of making huge heaps of ice to be preserved for cooling of their drinks, I observed, that by pouring water into an open pan, or into a flask gradually, some at one time, some at another, I could quickly freeze by this way a whole flask-full, when near half of a flask filled at once, though helped by art, was unfrozen. I observed also, that the ditches between *Southwark* and *Rotherhithe* had acquired an exceeding thickness of ice, caused by the flowing of the water in them at full tide; for new water being brought in by the tide, was there congealed to the thickness of some inches every ebbing and flowing. I observed also the ice on the banks of *Thames* above two yards thick; the inhabitants told me they had seen it three or four yards thick, which thus came to pass: the tide flowing in, and meeting with great flakes of ice, drove them to the banks, and lodged them on the ice there frozen; which flakes uniting there with the former ice, raised it to that excessive height or thickness. Besides, every one may observe in *London* streets, and elsewhere, in channels, where no constant current is, that water coming from the houses soon fill the channels with thick ice; for running but a little at a time, it freezeth almost as fast as it cometh thither. Nay, I have seen ice of some yards thickness in such places, where a small rill or stream of water gently falls on the side of a hill.

AMONGST those things, that will freeze, mortar and plaister of *Paris* were omitted; and thence it is, that plaisterers and bricklayers play all the winter.

My Lord *Verulam*, in his Natural History, says (and some from him have affirmed to me) that apples and eggs covered with a wet cloth will not freeze, but I find no difference in those, that are thus covered, and them that are not.

ADD to those, that sink upon congelation, all oils from animals, and from vegetables, that are extracted by expression or boiling.

ADD to those, that freeze not, water and sugar boiled to the consistence of a syrup, and also other syrups, none whereof I could ever take notice, or learn by others, that they would freeze. It is true, that water having an equal quantity of sugar dissolved in it, will freeze, but with a little more mixed therewith, freezeth not.

To try the effect of cold upon loadstones, I exposed several of them in the open air, and also within rooms, in the most severe weather, the needle being kept in a very warm place. At other times I exposed the needle to the cold air, keeping the stones warm, at other times both were exposed; but in none of my experiments could I conclude any thing certain as to their attractive faculty: for the sphere of their activity was found to be sometimes greater, and sometimes less, to a considerable difference, in ten several good stones employed for this purpose.

I ESSAYED also to find out a standard of cold, whereby to fit the tinged spirit of wine for the weather-glasses, and to that end made use of conduit-water, and the distilled waters of plantane, poppies, black-cherry, night-shade, scurvigrafs, and horse-radish; all which were first placed in the same room where a fire was kept, and then removed, and measured out into spoons in equal quantities, and also a drop of them dropped on the same bench: but though this was often tried, I could not make any sure inference from them. Only I observed, that the black-cherry-water did for the most part freeze first, but the other with very great uncertainty. The horse radish, and scurvigrafs-waters, were for the most part froze last. The best way to discover the very beginning of freezing of liquors, is to move a pin or needle through the liquors, whereby the ice will be raised, and become discernible, when the naked eye can discover none at all.

AN APPENDIX,

CONTAINING SOME

Promiscuous EXPERIMENTS and OBSERVATIONS

Relating to the Preceding

HISTORY of COLD.

Particulars referable to the II^d title.

1. **T**HE 26th of December in the morning, (being an extraordinary hard frost) there appeared to be quite frozen in my window near the fire, a phial full of the solution of minium, [made in the spirit of vinegar] so strong, that part of it was shot into saccharum Saturni: only at the top of them there was a little (less than a quarter of a spoonful) that looked yellow, and was not frozen, though, being poured out, it did not freeze like an oil.

2. A SOLUTION of gold, made with salts, and standing in the same window by the solution of minium, was also frozen.

3. THERE was exposed a pint phial full of the tincture of lignum nephriticum, which being frozen, there appeared no colour in the ice, when the phial was held from the light, as in the liquor before it was frozen.

4. THE often mentioned ingenious gentleman, Mr. Drummond, who was lieutenant-general of the Russian army, told me, that he had divers times seen brandy frozen in Russia, but the ice was not so hard as common ice.

5. A FRENCH surgeon, that waited upon an extraordinary ambassador to Moscow, being inquired of by me about the freezing of spirit of wine, answered me, he had good store of brandy frozen in the bottles, and that the unfrozen part, which was retired to the middle, was a spirit of wine by great odds stronger than ordinary brandy.

THE above-mentioned ambassador also told me, that it was usual in their country to have wine freeze.

Passages taken out of a letter of the Russian Emperor's physician to Mr. Boyle.

6. THE 7th of December, I put some very strong French brandy into a China cup, such as they drink coffee out of, and exposed it to the air: in three hours time it was turned into a crusty ice all about the sides of the cup, as if some cold blast had forced it abroad.

WATER and sallad-oil were exposed, the oil reduced to the firmness of tallow, the water not frozen.

Particulars referable to the III^d title.

1. **T**HE spirit of sal armoniac made with quick-lime, volatile oil of amber, a small quantity of oil of vitriol, solution of silver in aqua fortis, some diluted

with rain-water, and a phial full of weak *spiritus sanguinis humani*, were exposed two nights and a day to the cold. The event was, that the three former liquors appeared not to be at all frozen; the solution of silver was frozen, and the spirit of blood appeared almost totally turned into ice, (for something seemed to be unfrozen at the bottom, especially near the middle part of it) and the ice rose up high enough to fill the neck, and thrust out the cork, which I found lying upon the ice above the neck. (The glass was not hereby broken.)

2. UNRECTIFIED oil of turpentine, though being exposed all night in a single phial, it would not freeze; yet the same quantity (which was about two or three spoonfuls) being exposed in an open earthen pottinger, the upper part afforded ice of a pretty thickness, and figured almost like that of frozen urine.

3. A TRAVELLER, bred to be a physician, informed me, that in that part of *Scotland*, where his father now lives, there is a lake, out of which runs a little river, whose waters, neither in the one, nor the other, are ever frozen in the midst of winter (which in those northern parts is wont to be very sharp) and that lumps of snow and ice cast into that lake do readily dissolve there; and yet, as he answered me, this water doth not differ in taste from common water, as he divers times observed.

4. I WAS told by a colonel, that the soldiers this winter making use of fallad-oil to keep their locks from freezing, found they could not discharge; but being advised to hemp-oil, they froze not: neither will train-oil freeze, as it is told me.

Particulars referable to the VIth title.

1. **L**IEUTENANT G. Drummond told me, that he had often been fishing on ponds and lakes, that had been frozen over so strongly, that men might march with cannon over the ice; and yet these lakes were stored with live fish, as they found, when they broke the ice in several places, and drew their nets under the ice from one hole to another. The fish being drawn out, and packed up in this state, would continue good for a month, or better, without being either salted or dried.

2. AND it was remarkable, that the fishes being drawn out of the water found so great a difference between it and the cold air, that presently after, as soon as they had made some few leaps up and down, they were in a trice frozen as stiff as boards. He told me, that flesh and fish, if when it was frozen, it was thawed by the fire, would be quite spoiled, and the flesh would not only lose its natural taste, but would be incredibly hard and tough. But flesh and fish being kept in cold water, would there thaw, and become tender, and so grow fit to be dressed; yet he observed not, that in the thawing they acquired a coat of ice, as I told him I observed frozen eggs and apples do in *England*, when thawed in cold water.

3. He also told me, he had frequently seen men to have the end of their noses, and the upper part of their cheeks frozen, even when themselves were not aware of it, and that they were very careful not to enter into a stove, or come near the fire, to relieve themselves; because if they did, the frozen parts would be apt to mortify, and come off, but they would rub them well with snow, by which means they were thawed, though not without some trouble, yet without danger.

4. In *Lapland* they use another way to restore frozen limbs, viz. by making a certain kind of a cheese of deers milk, which they toast against the fire, and anoint

anoint the place affected with the *Caws-boby*, and that restores the frozen member immediately.

5. I HAD some *Cheeshire* cheefes, of which I desired the cheefemonger to choofe the fatteft and firmeft to refift the froft; but they were all frozen, as alfo a *Cbedder* cheefe of a hundred pound. I threw one into cold water, and in a quarter of an hour it gathered ice about it, or rather the water extracted the icicles out of it.

6. FISH thaws fooner and kindlier in cold water, than in the warm stove; but thawing in water is not fo proper to flesh, which muft have a time answerable to its bulk, or elfe it will never roaft further than it is thawed, roaft it never fo long, and carefully.

7. IT is their custom in *Ruffia*, efpecially at *Moscow*, to thaw their fish (before they put it to boil) by letting it lie in cold water, till it hath got a cake of ice about it, which they take off, and then put the fish into new cold water, and, when it is covered with ice, take it out again: this they continue to do, till the fish will occafion no more ice, and unlefs this be firft done, they find it will never be well boiled.

8. AN old fea-captain told me, that they very often met with large white bears, out of which they had fat enough, when well ordered, to yield a hogfhead of oil.

THE fame captain told me alfo, that white bears in or about *Greenland*, notwithstanding the coldnefs of the climate, have an excellent fcent; and that fometimes, when the fifhermen had difmiffed the carcafs of a whale, and left it floating on the waves three or four leagues from the fhore, from whence it could not be feen, thefe animals would ftand as near the water as they could, and raifing themfelves on their legs would loudly fuff in the air, and with the two paws of their fore-legs, as with fans, drive it as it were againft their fnout; and when they were (as my relator fupposed) fatisfied whence the odour came, they would caft themfelves into the fea, and fwim directly towards the whale, as my relator and others obferve, who had the curiofity to row at a diftance after them, to fee whether their nofes would ferve them for guides, when their eyes could not. He faw no other bears in thofe parts but white ones.

9. AN inquisitive doctör of my acquaintance bought at *Moscow* a fmall quantity of *Malaga* fack, that did as it were drain out at the bottom of a pipe or hogfhead, that had not been tapped, till it was (unawares to the owner) frozen. This liquor was much ftronger and better than the wine that afforded it, and the fame of its goodnefs making others croud to buy the remaining part of it, they found it, when the veffel was kept in a warm place, which thawed the ice, to be little elfe than ftrengthlefs phlegm. The fame phyfician had likewise fome ftrong beer frozen, whereof the part that refifted the cold (and was taken up near the top of the veffel) was ftronger than wine; but the reft, which had been once ice, was worth little or nothing. And as to thefe and the like glaciations, the fame doctör told me, that he obferved not the unfrozen liquor to retire always into the middle of the veffel, but rather (efpecially in fack) to be intermingled with the ice, almoft (as I guefs by his defcription) as honey is difperfed into an honey-comb.

10. SOME of the men of the old fea-captains, that had been in the frigid zone, being on fhore off *Greenland*, opened a barrel of good beer ftanding an end, and before they had drank much of it, the wind turning fuddenly fair, and being haftened aboard, they left the barrel behind them; and the next year coming again to the fame place to fifh for whales, fome of them went afhore in a fhallow, but were by extreme cold, and the interpoftion of fome ice, kept for a day or two from being able

able to get to the ship; by which accident their provision falling short, one of them remembred the barrel left behind, and coming to it, found it standing where they left it, but very hard frozen; whereupon they took a spit they had with them, and made a good fire, and therein heating it red-hot, they broached the frozen barrel with it, and when the spit had reached almost the middle part of it, there came out some quarts of a turbid liquor, but so strong and heady, that it made most of them drunk, and fall asleep for divers hours: after which waking, they did for curiosity sake stave the cask, and found, that about this spirituous liquor the waterish part of the beer had been hard frozen on every side, and the liquor had been altogether inclosed in thick ice. This relation I had from the old captain himself, who was employed in that voyage.

II. THE often mentioned governor of *Smolensco*, a famous fortrefs between *Russia* and *Poland*, told me, it often happened, that the French, and sometimes the Spanish wines, that are yearly brought from *Archangel* to *Moscow*, are so frozen by that time they come thither, that their owners are fain to break the cask, and cleave the ice with hatchets, and then they transport it from place to place in ordinary jars, (so hard it is frozen) and when they mean to reduce it to liquor again, they put it into another cask, and that cask into a deep hole made into the ice or snow, where it will slowly thaw, and be far less impaired, than if it had been thawed by the fire-side, or in a stove.

The Phænomena of an Experiment about Freezing, made by Mr. BOYLE, referable to the VIIth Title.

[This Paper was produced and read in the Royal Society, *Nov.* 23, 1671.]

WE took a bolt-glass, bigger than two turky-eggs, with a stem, which we caused to be drawn out at a lamp, till it was as slender as a goose-quill, or thereabouts. This vessel was filled with water, till the liquor reached to a pretty height in the slender part of the stem. Then I put it into a mixture of beaten ice and salt, in which mixture a cavity had been before made to receive a good part of it. But though upon our putting the glass into this cavity, there would at the very top seem to be some little shrinking down of the water, yet that was very small, and sometimes very scarcely, if at all, discernable; nor did the water afterwards appear to subside, and exhibit the other phænomena of freezing water mentioned by the excellent Florentine virtuosi: only when the liquor began below to be turned into ice, the quick ascent of it was manifest enough.

WHEREFORE we afterward caused the stem of a round bolt-head of clear glass, whose globous part was about $3\frac{1}{2}$ inches in diameter (taken on the out-side with calliper compasses) we caused, I say, this stem to be drawn out at the flame of a lamp, till it was at least as slender as a raven's quill; and the glass being filled with water to a competent height, that the expansions and dilatations of it might be very manifest in so very slender a pipe, we observed the ensuing phænomena.

FIRST, As soon as the globous part of the glass came to be as it were immersed in the frigorifick mixture, the water in the small stem instantly ascended, sometimes the length of a barley-corn, and sometimes less, and sometimes more. And this ascension was so hastily made, that it often begun and cesed almost in the same moment; after

after which the water began (though more slowly) to subside again to its former station, or thereabout, which, with other circumstances, made it very probable, that as the Florentine virtuosi ingeniously labour to prove, this sudden change proceeded rather from the constriction of the glass it self upon the first contact of the frigorifick mixture, than upon the sensible condensation of the water, which is not likely to be so suddenly effected.

SECONDLY, But whereas the newly named philosophers recite, as a constant phænomenon, that after the first subsidence of the water, and a subsequent pause for a pretty while, the water will be considerably depressed once more, before it begins to rise, we could very rarely indeed and scarce ever observe such a thing to happen, though I cannot suspect myself to have overseen it for want of attention. For my expectation of such a subsidence of the water, and its not appearing to me the first and second time, invited me to repeat the experiment several times one after another, and to look very attentively upon the water, and the marks carefully stuck on the side of the glass, to observe the motion of the liquor. And this seemed the rather strange to me, because I had often formerly observed in trials purposely made on other occasions, that water in convenient glasses would suffer some degree of condensation by the action of a frigorifick mixture, before it would begin to discover any ice in it. But having reiterated the experiment, till I, and those that assisted me, grew weary, I was fain to abandon it, leaving the prosecution of it to farther trials. For I dare not suspect, that so many eminent virtuosi, as ennoble the Florentine academy, could mistake, or misrelate a matter of fact, not once, but frequently, and uniformly taken notice of by them. And besides that, as I was saying, it is consonant to my own experiments on other occasions, in one of the glasses, wherein I tried this very experiment, I observed the second subsidence to be considerable. So that I cannot but suspect, that the so differing events of their trials and mine, as to this phænomenon, may proceed either from some peculiarity in the water they employed, or in the qualities of the glass, which the vessels I used were made of, or in the length and slenderness of the stem, considered together with the grossness of our English air in snowy weather, the pressure of the air having elsewhere been shewn by me to have a great stroke in divers condensations ascribed to cold: but whether to any of these things, or any other, that, which we have related, is to be reduced, future trial must determine.

THIRDLY, I observed for the most part, that after that subsidence, that almost immediately attends the first rising of the water, there would be for some time, more or less, a resting of the surface of the water in the same place, which continued till the upper part of the water began to ascend upon the beginning of the glaciation of its lower parts; and the duration of this pause or rest of the water I found to be very uncertain, being at some times at least twice or thrice as long as at other times, according as the frigorifick mixture did more or less vigorously operate upon the neighbouring water.

FOURTHLY, Though if the experiment was tried in glasses, whose stems were of an unusual bigness, the ascension of the water in the stem upon the glaciation of it in the globous part, was not so quick as to be very remarkable; yet when the stem was drawn out to such a slenderness, as was before described, the water, after having (as I lately noted) rested a while, would, upon its beginning to freeze beneath, ascend so hastily in the stem, as appeared strange enough, especially at the first sight: so that usually its progress upwards was very obvious, and sometimes made with such celerity, that in one minute of an hour, or much less, it would as it were shoot up several inches, and would have probably ascended much higher within

within half a minute more, if the slender part of the stem had been long enough to permit it.

FIFTHLY, But whereas the Florentine academicians inform, that there is a considerable intumescence or rising of the water, that does immediately precede glaciation, I never could satisfy my self, that I observed such a phenomenon. But in spite of frequently repeated trials (both alone, and before others) and of such a degree of attention as perhaps is not often employed even in more nice trials, it always appeared to me, that the ascension of the water was at least accompanied, if not rather preceded, by the actual glaciation of some parts of the water, that were most contiguous to the frigorifick mixture, or exposed to those portions of that mixture which were the most operative. Nor did it seem easy to me to assign any other, or at least, better reason of the ascension of the water in the slender stem, than the expansion, that is wont to accrue to water, upon its being actually turned to ice. It is true, that in slender stems the rising of the water will be manifest upon the production of so thin and transparent films of ice at the bottom, or some of the lateral parts of the globe the water is contained in, that it has often deceived even attentive eyes, and would have deceived me too, if the newly intimated conjecture at the reason of the intumescence of the water had not made me extraordinarily suspicious, and invited me to look upon the glass taken out of the frigorific mixture (and then wiped and held against the light) in so many differing postures, that though in some of them I could not, yet in others I did discover thin portions of ice, which sometimes I could within a minute or less make visible to others; because this ice upon thawing would not unfrequently emerge to the confines of the globe and stem, and there become easily enough discernible to a heedful eye. And though when I guessed, that the water was upon the point of beginning to freeze, I took it out of the frigorifick mixture, to try if it would afterwards freeze, or make the liquor in the slender pipe ascend; yet I never was so fortunate, as to observe any ascension of the water in the stem, but when there was actually some particles of ice in the ball, which though I newly took out of the mixture, as soon as I could perceive the least beginning of rising in the slender part of the stem, yet I regularly found more or less ice to have been already actually produced at the bottom or sides of the globe. The ascension of bubbles about the time of the water's congelation (especially if the glass were stirred) I do not here solemnly take notice of, it being an usual concomitant of the glaciation of water.

SIXTHLY, It was remarkable, and not unpleasant in our experiment, that not only if the glass were taken out of the mixture, very soon after the water began to ascend in the stem, the thaw, by reason of the extraordinary thinness of the ice, would begin so quickly, that within about half a minute, or sometimes much less, the liquor would begin to subside manifestly again. But when the water was sufficiently disposed to congelation, which it usually was, if the glass were put into the frigorifick mixture soon enough, after the total dissolutions of the little portions of ice newly mentioned, it would, upon the contact of the frigorifick mixture, though the globe were but half buried in it, begin to glaciare in a trice: insomuch that making observation by a minute watch, I have had the water shoot up in the stem within half a minute, so as to discover ice in it, and within two minutes (from first to last) to exhibit ice in most parts of the cavity of the globe.

Particulars referable to the VIIIth Title.

1. **T**WO sealed weather-glasses, one with spirit of wine, and cochineal, the other with a blue liquor made with spirit of man's blood, copper, and spirit of wine, were immersed in water, and kept there, till the glass, that contained the water, began to discover some ice within it: then, this water being thrown out, these thermometers were removed into oil of turpentine, (substituted for the water of the same vessel) and snow and salt being applied to the outside, the oil of turpentine (whose freezing in such a quantity and vessel we were not afraid of) was made as cold as we could. Whereupon the liquor in both the weather-glasses manifestly and considerably subsided beneath the former mark, and in one of them (which had the blue liquor) though it were but a short one, the subsidence was made half an inch; which still confirms, that the air may impart a higher degree of cold than is necessary to make water freeze, and than is always communicated by ice it self.

2. THE essential oils, as Spagyrist's call them, that are made of spices, and other spirituous materials by distillation in water, being, by reason of spirituousness, unapt to freeze; men could not observe, what effect a degree of cold capable of coagulating them would produce, in reference to their taking up more or less room, when congealed, than when fluid: some liquors having been found by experience to be expanded, others to be condensed, by being made to congeal or to concrete by cold. Wherefore considering, that oil of aniseed, though an essential oil, will lose its fluidity, not only sooner than hot liquors, but with a far less degree of cold than water it self, I thought this would be a fit subject to make trial upon; and accordingly having put a convenient quantity of this liquor into a round glass, about the bigness of a middle-size orange, furnished with a suitable stem, we put a mark, where the surface of the liquor rested, at about five inches above the ball. Then putting the glass into a vessel of water, made cold by powdered sal armoniack put to dissolve in it, we observed, that the oil in the stem subsiding did grow whitish, though by inclining the glass it was easy to discern, what part was yet fluid. In a short time after this the oil seemed totally coagulated into an opacous and very white body, (almost like sperma ceti) whose upper surface was near three inches beneath the mark formerly mentioned; so that the liquor appeared to have been not inconsiderably condensed by the operation of the cold. Which further appeared by this, that whereas the oil of aniseeds, whilst fluid, would swim upon water, this butter-like concretion would sink in it. And yet when I watched, I could observe, that upon the slow thawing of this thickned substance, there emerged from time to time several bubbles into the already fluid parts, divers of which bubbles might plainly be seen in the coagulated matter before their emersion; just before which several of them exhibited various and vivid colours, and very pleasant to behold.

Particulars referable to the Xth Title.

1. **A** FLAT bolt-head, sealed up with a stem about 17 inches in length above the superficies of the water, being set in the frigorifick mixture for eight or nine hours, the water ascended 15 inches and $\frac{1}{2}$, that I measured, and afterwards $\frac{1}{8}$ or $\frac{1}{4}$ of an inch, according to the measure of another; after which time neglecting it for one hour or more, while I was at supper, it blew off the sealed end of the glass quite round, and broke the bottom of it into many pieces, leaving almost all the whole body of the pipe uncracked.

2. WATER freed from air, by standing a good while in the exhausted receiver, being sealed up in a round bolt-head, whose pipe above the water was five inches or

a little more to the sealed apex, being set in a frigorifick mixture, exhibited an ice very prettily shaped, and without conspicuous bubbles; in less than two hours the water came to be impelled up four inches and $\frac{1}{4}$, and seemed to reach a little above the basis of the conical and sealed part; upon its breaking with a noise, the pipe was entire, and there appeared a good part of the water unfrozen under the ice, and the broken vessel seemed to smoke. Upon considering the shortness of the conical part of the glass, we guessed the air to have been compressed to about the 20th part of its former room.

3. THE globulous part of a glass-egg of about three inches (for it wanted $\frac{1}{10}$) in diameter on the out-side, was filled with water to the bottom of the stem, and then being carefully freed and sealed, was frozen from the bottom upwards, to try, whether the absence of the formerly incumbent air would not make the ice afford larger bubbles, and consequently take up more room, than otherwise it would, when the water was frozen in the ball; and a little way in the lower part of the stem we found, that (the remaining) water reached from the first station of the water about eight inches and $\frac{1}{2}$, the length of the whole stem being a very little more than ten inches and $\frac{1}{2}$. Being afterwards sealed up with air in it, and frozen, the ice reached not in it full four inches above the first station, though (if I mistake not) it was as well frozen this time as the former.

Particulars referable to the XIth Title.

1. **T**HERE was taken a strong cylinder of brass, whose cavity was two inches in diameter, into which was put a bladder of a convenient size, with a quantity of water in it, that the neck of the bladder (which I had taken care to have oiled) being strongly tied, the water might not get out into the cavity of the cylinder, nor be capable of expanding it self any other way than upwards. Then into this cylinder was fitted a plug of wood turned on purpose, which was somewhat less in diameter than the cylindrical cavity, that it might rise and fall easily in it. Upon the upper part of this plug was laid a conveniently shaped flat body, upon which were placed divers weights to depress the plug, and hinder its being lifted up by the expansion wont to be made in water that is made to freeze: then a frigorifick mixture being afterwards applied to the cylinder, it appeared within half an hour, or somewhat more, by a circle, that had been purposely traced on that side of the plug, where it was almost contiguous to the orifice of the cylinder, that the water in the bladder began to expand it self; and about two hours after having occasion to shew the experiment to some inquisitive persons, the circle appeared to have been heaved up, in my estimate about $\frac{1}{4}$, if not half an inch, notwithstanding all the weights, that indavoured to hinder the ascension, though these weights amounted to 115 pound; which were all the determinate weights we could then procure, besides brick, and some other things, that were estimated at five pounds more. Nor did I doubt, that a far greater load would not have hindered its expansion.

THE day after the above-mentioned experiment was made, to try the expansive force of freezing water, the same was reiterated after the manner above delivered, but with this difference, that having procured more weights, when the plug was lifted up $\frac{2}{3}$ of an inch, or somewhat better, (which plug began sensibly to rise within half, or three quarters of an hour, after the frigorifick mixture was applied) it was loaded with a weight of two hundred pounds, and a fifteen pound piece of lead, and other bodies, as boards, &c. to lay the weights upon; which being also weighed by themselves, came to fifteen pounds more, so that the whole amounted to 230 pounds: and if the hundred pounds were both of them (as their bulk and weight invited us to guess).

gues) of that sort of weights, which are called the great, a hundred containing a hundred and twelve pounds apiece, twenty four pounds must be added to the sum, which would thereby be made up 254 pounds.

2. AN iron barrel, being about 14 inches long, and having about $\frac{3}{4}$ of an inch diameter at the bore, and where the greatest thickness of the metal was $\frac{3}{16}$, and the least $\frac{2}{16}$, or somewhat better, being exactly stopped at the breech, and having a screw of a convenient length to stop it at the other end, was filled with water, and then the screw being put in, the barrel was buried in a mixture of beaten ice and salt for about two hours or longer; at the end of which time being taken out, it appeared to have a crack running somewhat oblique, by beginning at a place about three inches distant from the breech, and reaching to somewhat above six inches from the same: the crack was much more wide and gaping towards the middle of the barrel, which appeared also distended about that part; the ice being taken out in divers pieces, and held against a candle, seemed to have smaller bubbles than it would have had, if the water had not been pent up. But the minute bubbles were so numerous, that they made the ice more than ordinarily opacous.

3. A STRONG barrel of a gun of twenty four inches long, having the touch-hole stoppt, and a plug of iron, that was fitted to the muzzle, forcibly driven in, after the barrel had been filled with water, was put into a mixture of ice and salt, where within about three minutes by my watch, the lately named plug was with noise driven out of the end it had closed before; and when the same plug was afterward so driven in, that, to make the closure more perfect, the sides of the orifice of the barrel were hammered down upon the outward end of the plug, yet, within about three minutes more, the frigorifick mixture making the water expand it self, made it again drive out the plug, and that not only with noise, but with such violence, that we found it had broken a deal-board, that made the nearest part of an oblong box, (wherein the operation was performed.) Afterwards the iron plug being by the help of the fire and a hammer as it were incorporated into the barrel, the touch-hole came to be unstopped; and though a long iron nail was strongly driven into it, yet the plug being incapable to be driven out (as before) the frigorifick mixture being again applied to the barrel, quickly drove out the nail; which, lastly, being again forced in, and the commissure being for farther security brazed over, there was now no room left for the included water to expand it self much, but by breaking the barrel. But being my self called away, so that I could not stay to see the issue of the experiment, I left one to prosecute it, who soon after brought me an account, that within about a quarter of an hour (by his gues) after the barrel was put into the frigorifick mixture, though of that there was scarce left enough to cover it, it burst with a noise, and blew up the cover of the box (wherein the experiment was made) and the crack, which was two inches and a half long, was wide and gaping enough to let me see, that the barrel was of a very considerable thickness at the place, where it was broken.

A NEW pewter bottle, holding (by gues) about a pint, was filled with water, and then the top being screwed on, was put into a frigorifick mixture, wherein when it had lain (by our estimate) about $\frac{3}{4}$ of an hour, it was broken, not without noise; and being taken out, we found in it a crack almost an inch and half long, and in one place so broad as to amount to about $\frac{1}{4}$ of an inch. The bottle seemed to be every way distended, and particularly at the bottom, which was so swelled, that the bottle would not stand upright upon it.

One particular referable to the XIIIth Title.

THE old sea-captain told me, that out at sea, when the wind blew off from the great banks and tracts of ice, they could, by the extraordinary highness of the cold, (which would sometimes make the skin of their faces peel off) perceive, which way the ice lay, not only long before they could see it, but sometimes when they were fain to sail twenty leagues, before they could come to it.

Particulars referable to the XVth Title.

1. **T**HREE decoctions, one of sage, another of rosemary, and the third of parsley, were exposed in three small earthen pipkins to freeze, and were totally turned into ice, without any uncongealed liquor (that I could perceive) in the midst: nor did there appear in the ice any resemblance of the decocted plants, but the ice afforded by the decoction of sage had a very uneven superficies, and far more rugged than the two other portions of ice, which were neither of them smooth; and these (especially that of the sage) were observed manifestly to be less hard or solid than common ice.

2. **N**EWLY expressed juice of lemons being set to freeze in a wide-mouth-glass, afforded an ice very oddly figured, especially in one part, where it finely represented trees, as they are in winter, without leaves.

3. **H**ARD ice grossly beaten, having a great proportion of white table-salt put to it, and mingled with it, there arose from the mixture great store of whitish fumes, as thick (at least) as common smoke, which fumes played up and down all the mixture, and lasted a very considerable while; and all this, though the weather was very warm, and the experiment made in a room, where there was a very good fire.

4. **S**NOW-water being put to freeze in ice and salt, afforded an ice prettily figured, and had the bubbles produced in it so minute, that they hindered not the globe, which the ice constituted, from being more transparent, than would have been easily expected.

5. **W**E took a quantity (not inconsiderable) of ice, about two pound or more, and having partly reduced it into small lumps, and partly beaten it into small powder, we mixt with it a convenient proportion of bay-salt not powdered. This mixture, when it was suffered to lie still for a pretty while, did not appear to emit any thing from the superficial parts; but yet afterwards, when it came to be stirred here or there, there would in that part arise a smoke easy enough to be discerned, if the basin or platter, that contained the mixture, were held between the eye and the light. But if the whole body were stirred, then there would be excited so visible a smoke, as that it would not only overspread the surface of the vessel like a mist, but would overflow it on all sides for a good while. I use the word, *overflow*, because indeed the fumes did not only some of them ascend a pretty way into the air like smoke, but the greatest part of them by far, as soon as they were risen above the brims of the vessel, did fall down in streams, as if it had been a liquor poured out of a basin: so that the fumes seemed ponderous, almost like those, that one may observe, if he dip a piece of linnen in aqua fortis, and hang it up to dry; in which case the emitted steams will rather fall than rise. We also took notice, that those steams of our frigorifick mixture were far more plentiful than they seemed to be; for besides those, that were manifestly spilt out of the brims of the vessel, it was easy, by looking upon the mixture in a certain position in respect of the light; it was easy, I say, to perceive, that the whole cavity of the vessel, which was pretty deep, was all covered with those fumes,

fumes, that played upon it like thick mist upon a pond, not being able to pass over the brims of the basin. And this ascension of fumes, upon the stirring to and fro of the mixture, lasted a considerable while, and probably would have lasted longer, if partly weariness, and partly business, had not called me away.

I FORGOT to note, that when those steams came out the most plentifully, I applied my face to them, to observe, if I could feel them sensibly colder than the neighbouring air; but by reason of an impediment, I could not continue in a fit posture long enough to be sure, whether those effluvia would in due time feel sensibly cold or no. And though I applied a sealed weather-glass to the same fumes, and the tinted spirit seemed thereupon a little to subside, yet some circumstances make me *ἐπέχειν* till further trial.

6. THE old sea-captain, that sailed so often into the frigid zone, answered me, that when his ship was immured with ice, so that they could not in a long time get so much as a barrel of salt water, he made wells of the thick pieces of ice, to receive the liquor of the thawed ice, and found that water (though on the main sea) to be good fresh water, potable, and fit for dressing of their meat, and other uses, so that he never feared want of fresh water in those seas.

He also told me, that he had divers times fastened the ship to the pieces of ice, that reached under water to about 30 fathom, and that once he lay a good while by a piece of ice so thick, that it was on ground at fifty fathom, which he clearly perceived, both by sounding, and other ways of observing, that he acquainted me with. These deep pieces of ice (he said) were not very high above the water, insomuch that when I told him I had found by trial, that a cylinder of our *English* ice could have but about the tenth part of it above the water it was made of, and made to float in, he answered, that that proportion agreed well enough with his observation: and added, that the great depth of the ice proceeded from the successive snows, which, falling from the surface of it, depress it, and often within two or three days would itself melt, so as to shrink into a third or fourth part of its former thickness, and become hard ice. He likewise told me, that he had sailed to 82 degrees and a half of latitude, and answered me, that he was not mistaken in observing it, having had very good opportunity to do it by more than ordinary fit instruments, that he had carried along with him.

He told me too, that in some parts near the coast of *Greenland*, he found the variation of the compass to be 22 degrees, and not very long after to be scarce any at all; which strange alteration he knew not what to make of.

He told me moreover, that the last year sailing in the height of 77 degrees in the main sea, he was suddenly surrounded, and his ship locked fast up, only that it was driven by and with the ice, till the 7th of *June* following; and then, the ice opening a little, he made a shift to steer through it, and pursue his voyage; adding, that he observed, that that vast tract of ice being once broken, the fragments of it drove towards *Hudson's Straights*.

7. THE old sea-captain told me as strange a thing, which he had often, though not carefully observed, that great tracts of ice dead the wind; insomuch, that when he has been driven towards the ice by stormy weather, and feared to be in great danger, when they came near it, he unexpectedly found a kind of calm, that raised his wonder, and freed him from his fear. And at other times going out of the ice upon an almost smooth sea, when he had not yet gone far on it, he found, that there was a storm at distance from the ice: and mentioning this, as a very odd thing, to a *Dutch* navigator, who frequented those seas for the whale-fishing, he assured him, that he had several times observed this wonderful property of the ice.

One particular referable to the XVIIth Title.

IN *Siberia* (a northern province of *Russia*) the earth is thawed in summer but about two foot in depth, beneath which it continues frozen, and yet over this frozen part of the ground there groweth good corn. This I had from the *Russian* emperor's chief physician.

Particulars referable to the XVIIIth Title.

THE little sealed weather-glass being taken, was put into a glass broader at the top than the bottom, and greased on the inside with tallow, in which glass the ball in the inside of it was more than covered with water; and that water being frozen, notice was taken whereabouts the tinted spirit of wine rested in the stem: after which, the ice being newly taken off from the ball in the open air of an exceeding frosty morning, just upon the removal of the ice the liquor rose a little in the shank, as it useth to happen, when a glass-bubble filled with warm water is suddenly removed into cold: but presently after the tinted liquor, as I expected, subsided, not only as much as it had risen, but a pretty way (the shortness of the instrument considered) below the former mark. Which may confirm our observation, that the free air may communicate a more intense degree of cold than ice itself.

2. THE weather having continued for some time very cold, we placed two or three days ago a trusty sealed thermoscope (that was made by the standard weather-glass at *Gresham* college, which I therefore call the standard thermoscope, having used it for some years) in a cellar, where we had observed beer not to freeze in a very extraordinary sharp winter; and having looked upon it last night, which was, as the night preceding, very frosty, the wind being at east, we found, after ten a clock, that the tinted spirit of wine stood at two divisions, and at $\frac{1}{3}$ above the freezing mark; and this morning being a hard frost, it was found to stand much at the same height. Wherefore having caused it to be removed into the free air in the garden, it now being about nine of the clock, is fallen to the freezing mark, and consequently is subsided above two full divisions or inches beneath its station in the warm cellar. But nevertheless I hence observe, that the air in the cellar, notwithstanding the cold weather, is not (or is but very little) warmer than the air in my bed-chamber is wont to be in frosty weather: for the same weather-glass being usually kept in that chamber, the spirit of wine was wont to stand about two inches above the cipher or freezing-mark, in the morning before the fire was made, in case there was a moderate frost abroad; and in summer-time, when the weather was very hot, the tinted spirit has ascended to the eighth, ninth, and sometimes almost to the tenth mark.

3. THE last night being made extraordinary cold by frost, snow and wind, the standard weather-glass (before mentioned) was removed into the garden, and left there till this morning, when the tinted spirit appeared to be subsided above two divisions beneath the cipher or freezing-mark; so much greater was the cold of the air, than was absolutely necessary for the congelation of water. And yet the coldness of this very night did not by *Ἀντιπερίστασις* so increase the heat of the cellar, but that a phial, containing about two or three ounces of chymical oil of anise-seeds, being left there till nine of the clock this morning, was taken out without being thawed into a liquor: which argues, that the heat of the cellar was inferiour to that of the outward air in moderate seasons, since oftentimes, both in spring and autumn, oil of anise-seeds is by the warmth of the air kept in a fluid form: as this particular parcel of
oil

oil in the same phial, wherein it was exposed, was kept by the moderate warmth of my chamber many times this winter.

4. THIS morning (being *December 29, 1665*) a little before ten of the clock, the weather having been frosty (bating one mild, but rainy day) for near a fortnight, I took my sealed weather-glass out of my chamber-window, and having held it a while in the open air in the court, as also wetted it with water, to reduce it the sooner to the coldness of the ambient air, I caused one to pump so long, till to a younger eye than mine, the water, that came out of the pump, seemed to begin to reek; and then I held the ball of the weather-glass for a pretty while in the stream, that came out of the pump, and observed, that it made the tinted liquor considerably rise; and the more, the longer I kept it, till it was risen to the height of the cross, which I made in the frame. Then carrying it up to my chamber, though there was a good fire there, the spirit of wine began to subside again; thereby shewing, that the air in my chamber was colder than the reeking water, that had been pumped out.

5. ANOTHER time (being *Feb. 17, 1665*) after it had continued frosty weather three or four days, (if I mistake not the number) about nine or ten of the clock in the morning, I caused the water of a considerably deep well to be pumped for a good while upon it, after it had been kept a pretty while in the air; to bring it to the temper of that; the pump-water raised it by degrees, but slowly enough, to between four or five eighths of an inch higher than the pump-water at *Oxford* had been able to do. Then I carried the weather-glass to a spring, that was wont to smoke in frosty weather, and was not far from the pump; and having laid down the weather-glass, (that my hand might have no operation upon it) so as the ball was covered with water just at the spring-head; after it had rested there a good while, I found the tinted spirit but very little raised: so that in all it scarce exceeded five eighths above the height it had been brought to at *Oxford*.

AFTERWARDS in the same place I brought the weather-glass about noon to the north side of the house, to which the pump belongs; and letting it rest against the wall in the open air for half an hour or more, I found, that though it had been that morning a small frost, and though the sun did not shine out, yet by the weather-glass the air was just at the same degree of warmth (if not a little greater) that the water had been at the spring-head in frosty weather, when there was snow upon the ground; and consequently the air was then much hotter than the water had been in the pump at *Oxford*, where yet in very cold weather it uses to smoke.

Feb. 19, being the third day of the continuance of a moderate frost, I held the sealed weather-glass under the pump, and having caused the water to be pumped for a good while upon the ball of it, I found the tinted spirit rise as high with the warmth of the water, as it had done many weeks before in the depth of winter, by the warmth of the water of the same pump.

THE next day, being the fourth day of the frost, the neighbouring spring, which (as I was informed by those I sent to see) had not, during the precedent days, smoked, did smoke this morning, as one I sent to see, informed me, that another spring likewise did. About noon (the weather being fair, and the sun shining) I employed one to keep the ball of the weather-glass for a competent time covered with water just at the head of the spring, which had smoked in the morning; and by his relation, which was confirmed by the height of the tinted liquor, when I saw it, it appeared to have risen higher now by near or a full quarter of an inch, than I could make it do at the same spring-head divers weeks ago. But note, that this day the spring-water was a pretty deal warmer than the air, notwithstanding the

time and clearness of the day, as appeared by the subsiding of the tinted spirit, when brought from the spring to my chamber in a frosty morning, the ground being then covered (but not thickly) with snow.

6. HAVING inquired of an ingenious man, obliged to make some trials about cold, whether he had observed any thing to confirm or contradict the suspicion I published in the History of Cold about the coldness and temperature of the air; he gave me such an answer, that does notably confirm my conjecture. For he told me, that he had divers times observed in an exactly sealed weather-glass, that the tinged spirit of wine was higher at some times, when the weather was frosty, than at some other times, when it was not; and that having had occasion to keep his weather-glass with the ball in water, which was afterwards frozen, and continued ice for divers days, he warily brake the ice all about the ball, and removing it thence into the air, though it were in the same room, yet he found the liquor to descend from such a mark to such a mark; and having desired to see the instruments, I found the bigness of the ball to be like that of a middle-sized or somewhat large crab, and the stem to be about two foot and a half long: and having had the curiosity to measure the distance between the above mentioned marks, I found, that the liquor, by being removed out of the ice into the air, had subsided a pretty deal above three inches.

A relation given me by an ingenious gentleman, lately returned out of Poland.

7. ABOUT the 21, 22, and 23d of December 1669, old style, lying within three Polish miles of *Warsaw*, we saw every day the sun accompanied with two parhelions, the one eastward, the other westward, almost in a direct line, and distant about 8 or 10 times the diameter of the sun from it, and continued visible from near ten to twelve a clock, the weather being extreme cold, the air as clear, as possibly to be imagined, both night and day; and when the sun did shine, appeared as full of glittering spangles or particles of ice. The like hath been since, when it hath frozen very hard; which generally happens, the air being very clear, and as generally thaws, the heavens being clouded any time together.

8. THE old sea-captain, that failed so often to *Greenland* to fish for whales, assured me yesterday, being April 8, 75. that 18 or 19 years ago, he failed thither in the company of two Dutch ships, whereof one was a *Hollander*, but the other of *Emdden*: the names of the masters he told me. When they were come together as far as the place, where the *English* used to stay in *Greenland* (as I remember) the masters of the two ships desired this captain to give them leave to fish there with him; which, he told them, he could not possibly do, being a servant of the *Greenland* company, and employed there by them. Whereupon these masters told him, that they would then go seek their fortunes in an unknown world; and seven or eight weeks after, they came back to him, miserably distressed for want of fresh water and fuel, which they desired his leave to take upon the place; which being but an act of humanity and intrenched not upon the rights of the company, he willingly permitted. Whereupon they fell into discourse of their voyage; one of the masters told him, that coasting along the ice, in hopes to find some new land, and some place where they might freely, as well as conveniently fish for whales, they had at length come so far, that after the foggy and dark weather was cleared up, they took the latitude, and found it to be 89 degrees, so that they were within one degree of the pole.

THE old captain doubting of this the master brought him his journal, where the course was set down, which testified the same thing; and afterwards conferring with the master of the other ship, (for they failed in company) he agreed in the same relation,

relation. And the captain hearing, that the steersman of one of the ships was a *Scotsman*, he got to discourse with him, and saw his journal too, which agreed with what the others had declared. And afterwards one of the masters having occasion to come to *London*, and being there met accidentally by our captain, he brought him to some of the Northern company, to whom he averred the foregoing relation, of whose truth the captain seemed to me to be convinced. I asked him several questions relating to this odd story, to divers of which he could make no answer, having not asked them of his *Dutchmen*; but to some few things he gave answers, the substance whereof was, that though there were vast regions of ice towards the shores, yet where they found themselves so near the pole, the sea was very open and free; so that if wood and water had not begun to fail them, and if they had not feared their other provisions would not hold out, they might have made a passage perhaps as far as *Japan*. That from the north-east there came a great rolling sea, which one of the masters, that had been at the bay of *Biscay*, compared to that *Spanish* sea; and that the cold there was not extreme, but such as they could well endure, and complained no more of, than they did in *Greenland*. That sailing from *Greenland* towards the pole, they found the compass to vary a point, after they had sailed some degrees northward; then the variation of it was for a great while inconsiderable, and a while after that, it came to be two points. And lastly, when they came to be so near the pole, the declination increased strangely; so that at 89 degrees of latitude they found the variation to be four, not degrees, but points of the compass, and that towards the east.

9. THE old sea-captain told me, that they are in the seas frequently pestered with thick fogs extremely cold, which last some of them 10 or 12 hours, some a whole day, and others two or three days.

He told me, that lying at anchor in *Bell-Sound* on the coast of *Greenland*, near a mountainous rock, that was very high, he and some others made a shift to get up to the top, which he judged to have half a mile of perpendicular height; and when they came to the upper part of the mountains, they found the weather very clear, and the sky very serene; and it being then *June*, the sun shined so hot upon them, that he and others stripped themselves, and aired their shirts and naked bodies to cool themselves, seeing all the while a thick fog like clouds at the bottom of the hill; whither when they came down with store of fowl, that they had killed, they found the fog, as they left it, very dark, and exceeding cold.

A passage taken out of the Czar's doctor's letters.

10. *Aug. 29, 1664.* This winter we stayed at *Vologda* three months, which is north-east from *Moscow* some degrees. I expected the intense cold, which is usually felt there; but (as it happened) we had not three days of that, which we call winter-weather there, notwithstanding we were there in *December*, in which month it rained unusual and dangerous. The cold, which is so much talked of in books, hath been rare in these late years; for some *English*, which have lived there thirty years since, have observed such an alteration in the climate, that, except I had good confidence in the fidelity of their relations, being men of known worth and sobriety, I should not adventure to tell you, that in these thirty years the winters are become so mild, as the notable cold weather, which uses to freeze people in their way coming to market in several postures, as they were striking their horses, or guiding their sledges, hath been rarely felt, only to the freezing the noses and cheeks of some people, which may rather be termed a blast, than a settled intense cold.

11. THE warmer the room is made by day, the thicker is the hoar upon the glass at night, sometimes an inch thick, which I have seen. If it be a small frost, the nails only of the windows, which fasten the latten together, will be tipped with white; all the nails of insides of doors, and iron work, will be adorned with the frost, and going out of the door you will endanger your breath.

THE falconers here say, birds creep under the snow at nights.

ASSUREDLY the bears provide themselves with a cave against the winter. I have kept a bear two days without meat or drink, he still sucking his paws, making a lather with his tongue; and, had he not smelt the meat of the house, which made him craving and clamorous, no doubt he might have been kept much longer upon his fast.

12. A WIND from the sea there causes a thaw; so it does at *Archangel*, although it comes thither north.

I SHALL hereafter give you a catalogue of our plants, some of which are rare in *England*, but here in quantity, viz. *lilium convallium*, *pyrola*, *bifolium*, *polygonatum*, &c. I shall a little inform you concerning the vegetable lamb, which *Olearius* calls *baromets*.

13. But he told me they used very little physick, the air being so healthful, as that it is no rare thing to see people 80 or 100 years old; especially the poorer sort, that do not indulge themselves with strong drink.

14. THE same captain answered me, that in *Greenland* itself the north-east winds were colder than any other, which yet he ascribed in part to the situation of the country, those winds blowing over vast tracts of ice, without sea to mitigate the cold they communicated to the wind.

Particulars referable to the XIXth Title.

1. **L**IEUTENANT *G. Drummond*, who for some years was governour of *Smolensco*, told me, that he had many times barrels little less than our hogheads of strong beer, which being left night and day in the sledges upon the snow, would be frozen all about next the cask to a considerable thickness, so that the gimlet must pierce the ice a great way, before the vessel would be set abroach; but then the liquor, which came forth, would not only be much stronger than the beer was at first, but much more pleasantly tasted.

2. **L**IEUTENANT *G. Drummond* confirmed what others had told me, of the great noise, like the discharge of muskets, that they hear in the wooden houses, whose walls are made of fir-trees (unsquared, and only disbarked) upon very intense frosts; and he assured me, the great cracks or flaws, that appeared in the timber after these explosions, were barely clefts made by the bursting of the trees, without any splinters, or other parts of the wood thrown off from the body of the timber.

3. THE two Swedish Ambassadors assured me, that it is true, that in *Muscovy*, and some other northern countries also, the hares are, as in these parts, grey, (*grise*) but snow-white in winter; and that they begin to change colour in autumn, (and to recover it in the spring.) And the elder of them, Monsieur *Coyet*, being asked of me, if he himself had observed it, he assured me, that he had. It was likewise affirmed by the Swedish Resident, who was then present, and related it to me before them, that in the borders of *Muscovy* he had seen store of partridges milk-white: when I asked, whether they changed colour in summer, or were not rather constantly white: he answered me, he could not tell, it being winter when he was there. And when I inquired, whether there were not some other besides hares, that changed colour

colour according to the seasons, they all three told me, that squirrels, which in the summer are of the usual colour, do in the winter turn grey, and recover their colour in the following summer.

THEY were pleased also to send me word the next day by an ingenious gentleman, son to Monsieur Coyet, that they had forgot to tell me, that whereas the river *Duna* divides *Livonia* and *Muscovy*, on one side of the river the hares are of the ordinary colours, but on the other side white. So that when the hunters meet with any white hares on this side of the river, they say it is a *transfuga*.

4. AMONGST the odd effects of cold in *Russia*, and some other countries, where that quality reigns in winter, it is none of the least admired, that if a man be abroad in the air with a cane or staff furnished with a metalline head, the cold is so intense in that compact body, that the tip of the tongue being applied to the metal, they will stick, and be (as it were) glewed together, so that a man cannot sever them without great pain, and sometimes without leaving some of the skin of his tongue behind upon the handle of the staff; as it has been affirmed to me by eye-witnesses of unquestionable credit. The reason of this odd phenomenon, as far as I can conjecture, may be the great and sudden loss of agitation occasioned in the spittle and part of the tongue, by the great want of agitation in the parts of the metal that they touch. For if a bowl (for instance) of ivory meet in a direct line with another of the same bigness, that is already moving upon a billiard-table, it will communicate to it but a part of its own motion, and so retain the rest for itself: but if the impelled bowl were at rest, the impelling bowl will communicate to it all, or almost all its motion, and lose as much itself, as may appear by its remaining quiescent in the place of the other. I must not enlarge upon this subject of motion among bodies, that hit against others. But to apply the observation to my present purpose, it seems the metalline handle of the stick, by the intenseness of the cold, has its parts so deprived of motion, that when those of spittle and the tongue have communicated to them as much of their agitation as they can, there will not be between those three bodies agitation enough to keep the spittle fluid, which consequently being turned into ice, will stick to the two consistent bodies it adhered to, namely, the tongue and the metal, and by this means will fasten them together.

IN confirmation of this conjecture I shall add some other phenomena, which may be explicated by the help of it. And first we see, that in very frosty mornings the ice, that sticks to glass-windows, often appears in the form of trees, or otherwise oddly and prettily figured. This is vulgarly so explained, as if the cold produced those icy bodies on the outside of the glass, through which, some fancy, that the vapours of the warm room penetrate: but it is plain, that this ice uses to be formed within the room, as I have divers times observed, either by the thawing of it, or by scraping it off; so that it appears to be formed of vapours, which being carried to and fro by the air, when they chance to pass along the glass-panes of the windows, which by the cold, that reigns in the external air in frosty weather, have lost the wonted agitation of their parts, these vapours transfer so much of their motion to the glass, that they retain not enough to keep them fluid; the consequence of which is their being turned into ice, which in very cold countries may be far thicker than it uses to be here: insomuch that a learned acquaintance of mine assured me, that he had in *Russia* observed in some stoves, (where it is like the heat produced store of vapours) that the ice on the inside of the windows was near an inch thick.

A note out of Martinius, in his account of China.

5. In Peking elevatione Poli 42. gr. per integros quatuor menses factio circa Novembris medium initio, flumina omnia adeo duro concreverunt gelu, ut currus, equosque, ac gravissima quæque onera glacies tuto ferat. Hæc plerumque concretio uno fit die; cum non nisi pluribus, & quidem ab inferiori superficie prius, fuit liquefactio. p. 27. ‘Martinius in his account of Peking p. 27. tells us, that although the pole be not elevated above 42 degrees, yet for four whole months, from the middle of November, all the rivers are so bitterly frozen over, that the ice will safely bear coaches, and horses, and all the heaviest burdens. This congelation is for the most part made in one day; but the melting of the ice requires many, and begins from the lower surface.’

A note taken out of Martinius Cromerus his Polonia, lib. 1. p. 53, 54.

6. Tanta est enim vis frigoris in his regionibus interdum, ut radicitus arescant arbores, & aqua ex editiori loco effusa, priusquam terram contigerit, in glaciem concreverat. Lacus quidem, & paludes, & flumina duobus tribusve mensibus hibernis, nonnunquam autem vel in quintum vel sextum usque concreta glacie, non modo peditibus, verum etiam equitibus, & curribus ac plaustris, quamvis oneratis, multis simul longo spatio pervia & secunda præbent itinera. Equidem quodam tempore ultimo die mensis Martii Viistulam in Masovia per firmam adhuc glaciem, cum curru & quadrigis, & aliquot equitum comitatu transivi. Hæc etiam præteritâ hyeme in Prussia glacialis piscatio in lacubus post initium Novembris cæpta, duravit per totum Martium, gelu autem per totum Aprilem. ‘So great is the violence of cold sometimes in these countries, that trees wither at the roots; and water poured out from an high place, turns into ice before it comes to the ground. And truly the lakes, and marshes, and rivers are so frozen for two or three months in winter, and sometimes for five or six, that not only footmen, but also horsemen, and coaches, and waggons, though loaded, may for a long space freely and securely pass over them. Truly once I passed over the *Weissel* in *Masovia* upon the firm ice the last day of *March*, with a coach and four horses, and a retinue of some horsemen; and this last winter in *Prussia* the fishing in the ice began in the lakes after the beginning of *November*, and continued all *March*, but frost lasted all *April*.’

A note taken out of Cromerus's Polonia, lib. 1. p. 68.

In cæteris lacubus, atque etiam in majoribus piscinis & fluminibus tempore hyberno commodiores ferè sunt piscationes, quàm æstate, pertusâ certis intervallis glacie, retique per majus foramen in aquam immisso: quod longis funibus ad perticas alligatis hominum equorumve operâ longo spatio in diversum tractum, coeuntibus rursus piscatoribus, alio foramine refertum extrahitur. ‘In other lakes, and in the larger fish-ponds, and rivers, fishing is more commodious in winter than in summer, the ice being broken in some places, and a net cast into the water through a great hole, which by long ropes tied to poles, men and horses draw different ways for a considerable space; and then the fishermen meeting together, take it up well filled at another hole.’

7. An ingenious physician confirmed to me upon trial, that the pummel of a sword, that was exposed to the winter-air in *Moscow*, would stick to his tongue, that touches it therewith, and fetch off the skin, if he forcibly and suddenly pulled it away.

8. A GENTLEMAN, that came lately from *Warsaw*, told me, that in one night, or rather twelve hours, he observed this winter the ice next the surface of the water to reach four inches directly downwards.

9. THE old sea-captain told me, that when he was in *Greenland*, and in those arctic regions, his appetite was so great, that he could well eat more in one day, than he could in a week or ten days here; and that accordingly he and others found themselves stronger there than here, and more prone to venereal pleasures.

HE told me also, that sailing with intention to make some discovery into the arctic circle, that after having sailed a great while through a sea exceeding blue and deep, they were as much surprized to find themselves on a sudden upon a sea black almost like ink, which much frightened them, none of all their wanderers having met with a sea of that colour. This made them, after many disputes and doubts, resolve to sound both from their ship and shallop, but they could find no ground at seventy fathom.

10. A BOTTLE of strong sack, about two thirds filled, cracked, and the wine was frozen, viz. the phlegm, but no ice on the top, as in water; nor does the phlegm ever ascend to the top, to be frozen in an entire body.

THIS sack being presently thawed, lost its vigour, and so will any thing else.

11. THE frost in these parts pierces the ground five foot, which the undertakers for digging a cellar for a friend of mine found by woful experience, being forced to make their way by fire, and sometimes by cleaving the earth with wedges like a rock.

THE ice in *Siberia* in the river *Ob* is said to be a fathom and a half thick, where they have in the whole year but twelve weeks of degelation.

THE rivers, that I have travelled over, have breathing-places for a mile, sometimes half a mile, and a quarter, out of which comes a fume like that of the *Cross-Bath* or *King's Bath* at the *Bath*. The like out of a cellar upon the opening of the door, enough to suffocate a man, if taken unawares.

DEATH by cold is not painful, especially if the cold be very intense; as a friend of mine told me, who waiting upon his uncle here (a colonel) in quality of a page, he sat upon the side of the sledge, as servants do, and it being very cold, he ran to get himself some heat in his feet, and afterwards returned to sit upon the sledge, and found himself surprized with the cold, but had not the power to prevent the danger of suffocation by calling for help; yea, rather he seemed to be pleased with falling into a pleasing sleep, and so tumbled back upon his uncle's legs, which raised a suspicion in him, that his cousin was frozen: and so making haste to the next village, he rubbed him all over with snow strenuously enough, and afterwards brought him into a warm room, which by degrees revived him, he feeling himself afflicted and pained in all his limbs with such a tingling numbness, as they use to have who leaned too hard upon their elbows, but much more painful and amazing.

12. THAT cold dries excessively, appears by the story of the cheeses, and stock-fish, which is dried in the wind, some of which is sprinkled with salt. The earth will cleave with it, but I never observed it cracked with such monstrous hiatus, as *Olearius* reports; yet that may be true also. Where there is frost long before the snow comes, the ice in rivers will have cracks.

ABOUT the middle of *December* being at *Newslave* in my lodging in a morning before day, the house being new, and exposed to the north-east wind, it gave a crack like a musket.

Particulars referable to the XXth Title.

1. A SEALED glass-bubble with quicksilver in it weighed in the air, and being carefully counterpoised in water, that to my hand, whilst I was sitting by the fire-side, felt luke-warm, did, after snow and salt were applied on the out-side of the glass, that held the water, weigh $\frac{1}{2}$ of a grain, or somewhat better, before or just when there appeared a little film of ice on the inside of the glass, containing the water, less than it did when the bubble was first put in.

2. A GLOBE of snow, rammed into the mould of just one inch diameter, weighed 112 grains.

3. A BULLET of ice of an inch diameter, made in the same mould, amounted to 2 drachms, 5 grains.

4. AFTER a long frost and snow, a great deal of new snow being fallen last night, the liquor in the gaged weather-glass stands beneath the first mark, argues a more than ordinary frost: and yet the mercury in the baroscope stands at near $\frac{2}{3}$ beneath 29 inches, to which perhaps the high wind may contribute.

5. FOUR ounces of snow made up in a lump, were counterpoised in a pair of good scales, and exposed in a frosty night after eleven o'clock without being taken out of the balance: the next morning between 9 and 10, there appeared a decrement of 29 or 30 grains, which seemed to have evaporated from the snow itself: for though a small portion of it (probably late in the morning) were melted in the scale, yet that liquor was but little, and amounted not to 8 grains, which was not a third of the weight, which the snow-ball had lost; but supposing the decrement would be greater, if the snow had a greater superficies, in respect of the bulk thereof, I caused the next night the following trial to be made, not being able to assist at it my self.

THERE was taken 3ij of snow, which being made up into a kind of flat cake, was exposed all night, which was frosty, in the above-mentioned balance, and the next morning about eight a clock there appeared to have been lost 55 grains, no water being found in the scale; and about two hours after, the decrement was found to be about 63 grains, none of the snow appearing to have melted in the scale.

One particular referable to the XXI^a Title.

THE *Samejodes* clothe themselves with *renes* skins, the hair outward, which they find to be the warmest way: and I have found a pair of *cangies* (which are like high shoes with pecked toes of old *Chaucer's* fashion, which we wear without the leather) to be better than a pair of furred gloves. They are only proper for the sledge, yet one may walk in the snow with them, which is so dry a snow, if it be duly cold weather, as it will not wet at all, nor endamage a scarlet cloak covered all over with it, but brush or shake off like chaff.

OBSERVABLES upon a MONSTROUS HEAD.

First Printed in the *Philosophical Transactions*, N^o v. p. 85.

For Monday, July 3, 1665.

THIS was the head of a colt, represented in the annexed figure 4, first viewed by Mr. Boyle, who went into the stable where the colt lay, and got the head hastily and rudely cut off, the body thereof appearing to his eye compleatly formed, without any monstrosity to be taken notice of in it. Afterwards he caused it to be put into a vessel, and covered with spirit of wine, thereby chiefly intending, to give good example, together with a proof, that by the help of the said spirit, (which he hath recommended for such properties in one of his Essays of the Usefulness of Natural Philosophy) the parts of animals, and even monsters, may in summer itself be preserved long enough to afford anatomists the opportunities of examining them.

THE Head being opened, and examined, it was found,

FIRST, That it had no sign of any nose in the usual place, nor had it any, in any other place of the head, unless the double bag C C, that grew out of the midst of the forehead, were some rudiment of it.

NEXT, That the two eyes were united into one double eye, which was placed just in the middle of the brow, the nose being wanting, which should have separated them, whereby the two eye-holes in the skull were united into one very large round hole; into the midst of which, from the brain, entred one pretty large optick nerve, at the end of which grew a great double eye; that is, that membrane called sclerotis, which contained both, was one and the same, but seemed to have a seam, by which they were joined, to go quite round it, and the fore or pellucid part was distinctly separated into two corneas by a white seam that divided them. Each cornea seemed to have its iris, (or rain-bow like circle) and apertures or pupils distinct; and upon opening the cornea, there was found within it two balls, or crystalline humours, very well shaped: but the other parts of it could not be so well distinguished, because the eye had been much bruised by the handling, and the inner parts confused and dislocated. It had four eye-brows, placed in the manner express'd in figure 4, by *a a*, *b b*; *a a* representing the lower, and *b b*, the upper eye-lids.

LASTLY, That just above the eyes, as it were in the midst of the forehead, was a very deep depression, and out of the midst of that grew a kind of double purse or bag, C C, containing little or nothing in it; but to some it seemed to be a production of the matter designed for the nose, but diverted by this monstrous conception; perhaps the processus mammillares joined into one, and covered with a thin hairy skin.

Some ANATOMICAL OBSERVATIONS of MILK found in
Veins instead of BLOOD; and of GRASS found in the
Wind-pipes of some Animals.

First Printed in the *Philosophical Transactions*, N^o vi. p. 100.
For Monday, November 6, 1665.

A CURIOUS person wrote not long since from *Paris*, that there they had, in the house of a physician, newly opened a man's vein, wherein they found milk, instead of blood. This being imparted to Mr. *Boyle* at *Oxford*, his answer was, that the like observation about white blood had been made by a learned physician of his acquaintance; and the thing being by him looked upon as remarkable, he was desirous to have it very circumstantially from the said physician himself, before he would say more of it. The next month may bring us in this account.

THE other particular mentioned in the title of this head, came in a letter sent also by Mr. *Boyle*, in these words:

I SHALL acquaint you, that two very ingenious men, Dr. *Clarke* and Dr. *Lower*, were pleased to give me an account of a pretty odd kind of observation: one of them assuring me, that he had several times, in the lungs of sheep, found a considerable quantity of grass in the very branches of the aspera arteria: and the other relating to me, that a few weeks since, he, and a couple of physicians, were invited to look upon an ox, that had for two or three days almost continually held his neck streight up, and was dead of a disease, the owner could not conjecture at; whereupon, the parts belonging to the neck and throat, being opened, they found, to their wonder, the aspera arteria in its very trunk all stuffed with grass, as if it had been thrust there by main force: which gives a just cause of marvelling and inquiring, both how such a quantity of grass should get in there; and how, being there, such an animal could live with it so long.

Of a Place in *England*, where, without petrifying Water,
WOOD is turned into STONE.

First Printed in the *Philosophical Transactions*, N^o vi. as above.

THE same searcher of nature, that was alledged in the immediately precedent observations, did impart also the following, in another letter from *Oxford*, where he saith,

I WAS a while since visited by a gentleman, who tells me, that he met with a place in these parts of *England*, where, though there be no petrifying spring (for that I particularly asked) wood is turned into stone in the sandy earth itself, after a better manner than by any water I have yet seen: for I had the curiosity to go to look upon pieces of wood he brought thence, and hope for the opportunity of making some trials to examine the matter a little further, than I have been yet able to do. Thus far that letter.

SINCE which time, he was pleased to give this further information of the same matter, with a manifest of some other particulars, belonging to this subject, in these words :

I WAS lately making some trials with the petrified wood I told you of, which I find to be a very odd substance, wonderfully hard and fixed. If I had opportunity to reprint the *History of Fluidity and Firmness*, I could add divers things about stones, that perhaps would not be disliked ; and I hope, if God vouchsafe me a little leisure, to insert several of them in fit places of that history, against the next edition. Here is a certain stone, that is thought to be petrified bone, being shaped like a bone, with the marrow taken out ; but with a fit menstruum, I found that I could easily dissolve it, like other soft stones : and possibly it may prove as fit as osteocolla, for the same medicinal uses.

A Farther ACCOUNT of an OBSERVATION about
WHITE BLOOD.

First Printed in the *Philosophical Transactions*, N^o vi. p. 117.

SINCE the printing of the former sheet, there is this farther account from the same hand, Mr. Boyle.

I HAVE at length, according to your desire, received from the ingenious Dr. Lower an account in writing of the observation about chyle found in the blood ; which though you may think strange, agrees well with some experiments of his and mine, not now to be mentioned. The relation, though short, comprizing the main particulars of what he had more fully told me in discourse, I shall give it you with little or no variation from his own words.

A MAID, after eating a good breakfast, about seven in the morning, was let blood about eleven the same day in her foot ; the first blood was received in a porringer, and within a little while it turned very white ; the last blood was received in a saucer, which turned white immediately, like the white of a custard. Within five or six hours after, he (the physician) chanced to see both, and that in the porringer was half blood and half chyle, swimming upon it like a serum as white as milk, and that in the saucer all chyle, without the least appearance of a drop of blood ; and when he heated them distinctly over a gentle fire, they both hardened : as the white of an egg when it is heated, or just as the serum of blood doth with heating, but far more white. This maid was then in good health, and only let blood because she never had her courses, yet of a very florid clear complexion.

HYDROSTATICAL PARADOXES,

MADE OUT BY

NEW EXPERIMENTS,

For the most part PHYSICAL and EASY.

The PUBLISHER'S ADVERTISEMENT to the READER.

WHEN the author writ the following treatise, he had a design, as appears by some passages in the preface, to publish together with it some things, which he had divers years before provided for an Appendix to his Physico-mechanical treatise about the Air: but part of the Appendix consisting of experiments, which the author has several times made, but trusting to his memory, did not think it necessary to record, when he came to recollect particulars, he found, that some years, which had passed, since divers of them were tried, and variety of intervening occurrents, had made it unsafe for him to rely absolutely upon his memory for all the circumstances fit to be set down in the historical part of the design'd Appendix. And therefore he resolv'd to repeat divers experiments and observations, that he might set down their phaenomena, whilst they were fresh in his memory, if not objects of his sense. But though, when he writ the following Preface, he did it upon a probable supposition, that he should seasonably be able to repeat the intended trials; yet his expectation was sadly disappointed by that heavy, as well as just visitation of the plague, which happened at *London*, whilst the author was in the country; and which, much earlier than was apprehended, began to make havock of the people at so sad a rate, that not only the glass-men there were scattered, and had, as they themselves advertised him, put out their fires, but also carriers, and other ways of commerce (save by the post) were strictly prohibited betwixt the parts he resided in, and *London*; which yet was the only place in *England*, whence he could furnish himself with peculiarly shaped glasses, and other mechanical implements requisite to his purposes: and the same calamity continuing still, without yet affording us any certain ground of determining, when it will end, the author chuses rather to suffer the following Paradoxes to come abroad without the Appendix, (which is no way necessary to them, whatever they may be to it) than any longer put off those ingenious persons, that solicited the publication of them.

The P R E F A C E.

THE rise of the following treatise being a command imposed on me by the Royal Society, the reader will, I hope, need no more, than this intimation, to keep him from wondering to find some passages worded as parts of a discourse pronounced before

before an assembly; it being not unusual (though not necessary) to present either in writing, or by word of mouth, together with the experiments made before that illustrious company, an historical account of them.

BUT, because it is probable, that some reader will desire to be satisfied about other particulars relating to the publication of this treatise, I presume it will not be amiss, both to say something of the reasons, why I publish it as the first part of the present Appendix to my *Physico-mechanical Experiments*, and to give some account of the manner of writing it.

I HAD quickly both an opportunity, and an invitation to enlarge the papers, I was to read, beyond the limits of a bare description of the phenomena, and matters of fact, by my having been, through some intervening accidents, so hindered from exhibiting them all together, that I was desir'd to bring in an account in writing, that might be register'd (how little soever worthy of such company) in the Society's collection of philosophical papers, for the sake of those members, who could not be present at all the experiments; so that, finding some enlargements expected from me, I was easily induced to add the explications of the phenomena I described, whilst I perceiv'd, that by a small addition of pains I might much gratify divers ingenious friends, that were not so well versed in Hydrostaticks, as in the other parts of real learning.

HAVING thus been induced to enlarge the account of my experiments, till it had attained the bulk it is now arrived at, I confess I was, without much difficulty, persuaded, that to suffer it to pass abroad * in the company of the Appendix, where-with it is published, would not prove unacceptable to the curious, no more than an improper introduction to the rest of my Appendix, and that for several reasons.

FOR, first, the Hydrostaticks is a part of philosophy, which, I confess, I look upon as one of the ingeniousest doctrines, that belong to it; theorems and problems of this art being most of them pure and handsome productions of reason, duly exercised on attentively considered subjects, and making in them such discoveries as are not only pleasing, but divers of them surprising, and such as would make one at first wonder, by what kind of ratiocination men came to attain the knowledge of such unobvious truths. Nor are the delightfulness and the subtilty of the Hydrostaticks the only things, for which we may commend them: for there are many, as well of the more familiar, as of the more abstruse phenomena of nature, that will never be thoroughly understood, nor clearly explicated by those, that are strangers to the Hydrostaticks; upon whose principles depend, besides many other things, the explications of most of the physico-mechanical experiments, we have ventured to present the publick, and the decision of those many controversies, which they and the phenomena of the Torricellian experiment have occasioned among the modern inquirers into nature.

BUT the use of this art is not alone speculative, but practical, since not only the propositions it teaches, may be of great importance to navigation, and to those that inquire into the magnitudes and gravities of bodies, as also to them that deal in salt-works; but that the Hydrostaticks may be made divers ways serviceable to the chymists themselves, to whose art that doctrine seems to be so little of kin, I might here manifest, if I could think it fit to transcribe, what I have † elsewhere delivered to that purpose.

* About this passage, see the Publisher to the Reader.

† Chiefly in several places of the unpublished part of the *Treatise of the Usefulness of Experimental Philosophy*.

BUT that, which invited me to write something of this part of philosophy, is, not only that I think it considerable, but that, notwithstanding its being so, I find it but very little, and not very happily cultivated. For, being not looked upon as a discipline purely mathematical, the generality of mathematicians have not in their writings so much as taken notice of it, much less improved it. And since the admirable *Archimedes*, who, in his little tract *De Insidentibus Humido*, has left us three or four very excellent propositions, (but proved by no very easy demonstrations) among divers others, that have more of geometrical subtilty than usefulness; those mathematicians, that (like *Marinus Ghetaldus*, *Stevinus*, and *Galileo*) have added any thing considerable to the Hydrostaticks, have been (that I know of) very few; and those too have been wont to handle them rather as geometricians, than as philosophers, and without referring them to the explication of the phænomena of nature. And as for the Peripateticks and other school-philosophers, though on some occasions, as when they tell us, that water weighs not in water, nor air in air, they deliver assertions about matters belonging to the Hydrostaticks; (which term, in this treatise, I often take in a large sense, because most of the things delivered about the weight of bodies, may, by easy variations, be made applicable to other fluids) yet they are so far from having illustrated, or improved them, that they have but broached, or credited, divers of the most erroneous conceits, that are entertained about them. So that, there being but few treatises written about the Hydrostaticks, and those commonly bound up among other mathematical works, and so written, as to require mathematical readers, this useful part of philosophy has been scarce known any farther, than by name, to the generality even of those learned men, that have been inquisitive into the other parts of it, and are deservedly reckoned among the ingenious cultivators of the modern philosophy. But this is not all; for some eminent men, that have of late years treated of matters hydrostatical, having been prepossessed with some erroneous opinions of the peripatetick school, and finding it difficult to consult experience about the truth of their conclusions, have interwoven divers erroneous doctrines among the sounder propositions, which they either borrowed from *Archimedes*, and other circumspect mathematicians, or devised themselves; and these mistakes being delivered in a mathematical dress, and mingled with propositions demonstrably true, the reputation of such learned men, (from which I am far from desiring to detract) and the unqualifiedness of most readers to examine mathematical things, has procured so general an entertainment for those errors, that now the Hydrostaticks is grown a part of learning, which it is not only difficult to attain, but dangerous to study.

WHEREFORE, though neither the occasion and design of this treatise exacted, nor my want of skill and leisure qualified me to write either a body, or elements of Hydrostaticks; yet I hoped I might do something, both towards the illustrating, and towards the rescue of so valuable a discipline, by publishing the ensuing tract; where I endeavour to disprove the received errors, by establishing paradoxes contrary to them, and to make the truths the better understood and received, partly by a way of explicating them unemployed in hydrostatical books, and partly by confirming the things I deliver, by physical and sensible experiments. And over and above this, the more to recommend Hydrostaticks themselves to the reader, I have, besides the paradoxes opposed to the errors I would disprove, taken occasion by the same way to make out some of the usefulest of those hydrostatical truths, that are wont to seem strange to beginners.

IF it be here demanded, why I have made some of my explications so prolix, and have on several occasions inculcated some things; I answer, That those, who are not

used to read mathematical books, are wont to be so indisposed to apprehend things, that must be explicated by schemes; and I have found the generality of learned men, and even of those new philosophers, that are not skilled in mathematicks, so much more unacquainted, than I before imagined, both with the principles and theorems of Hydrostaticks, and with the ways of explicating and proving them, that I feared, that neither the paradoxes themselves, that I maintain, nor the hypotheses about the weight and pressure of the air, upon which little less than my whole pneumatical book depends, would be thoroughly understood without such a clear explication of some hydrostatical theorems, as, to a person not versed in mathematical writings, could scarce be satisfactorily delivered in few words. And therefore, though I do not doubt, that those, who are good at the most compendious ways of demonstrating, will think, I might in divers places have spared many words without injury to my proofs; and though I am myself of the same mind I expect to find them of; yet I confess, that it was out of choice, that I declin'd that close and concise way of writing, that in other cases I am wont most to esteem. For writing now not to credit myself, but to instruct others, I had rather geometricians should not commend the shortness of my proofs, than that those other readers, whom I chiefly designed to gratify, should not thoroughly apprehend the meaning of them.

BUT this is not all, for which I am to excuse myself to mathematical readers. For some of them, I fear, will not like, that I should offer for proofs such physical experiments, as do not always demonstrate the things, they would evince, with a mathematical certainty and accurateness; and much less will they approve, that I should annex such experiments to confirm the explications, as if suppositions and schemes, well reasoned on, were not sufficient to convince any rational man about matters hydrostatical.

IN answer to this, I must represent, that in physical enquiries it is often sufficient, that our determinations come very near the matter, though they fall short of a mathematical exactness. And I chuse rather to presume upon the equity of the reader, than to trouble him and myself with tedious circumlocutions, to avoid the possibility of being misunderstood, or of needing his candour. And we see, that even mathematicians are wont, without finding any inconvenience thereby, to suppose all perpendicular lines, made by pendulous bodies, to be parallel to one another: though indeed they are not; since, being produced, they would meet at the centre of the earth. And to presume, that the surface of every calm water, in a vessel, is parallel to the horizon, and consequently a plane; though, in strictness, themselves think it the portion of a sphere; and though also I have usually observed it to be higher, where it is almost contiguous to the sides of the vessel, than it is in other places.

MOREOVER, since we find, that though water will be uniformly raised in pumps to several heights, but not to thirty-five foot; and will, in ordinary open pipes, be almost of the same level within and without, but not if the pipe be extraordinary slender; upon these, and divers other such considerations, I may have sometimes made use of expressions that seemed not positive and determinate enough to be employed about matters, to which mathematical demonstrations are thought applicable. But I elsewhere give an account of the scruples I have about such demonstrations, as they are wont to be applied to physical matters. And, in the present paradoxes, I think I have not done nothing, if in my hydrostatical explications I have made it appear, that in experiments made with such liquors and glasses, as I employed, the rules will hold without any sensible, or at least any considerable error; for thereby we may learn the truth of many things, for the main, though in some we should not have

have attained to the exactness of measures, and proportions, which yet our endeavours may assist others to arrive at.

AND as for my confirmation of hydrostatical propositions by physical experiments, if some readers dislike that way, I make no doubt, but that the most will not only approve it, but thank me for it. For though, in pure mathematicks, he, that can demonstrate well, may be sure of the truth of a conclusion, without consulting experience about it; yet because demonstrations are wont to be built upon suppositions or postulates; and some things, though not in arithmetick or geometry, yet in physical matters, are wont to be taken for granted, about which men are liable to slip into mistakes; even when we doubt not of the ratiocination, we may doubt of the conclusion, because we may of the truth of some of the things it supposes. And this consideration, if there were no other, will, I hope, excuse me to mathematicians, for venturing to confute some reasonings, that are given out for mathematical demonstrations. For I suppose it will be considered, that those, whose presumed demonstrations I examine, though they were some of them professors of mathematicks, yet did not write merely as mathematicians, but partly as naturalists; so that to question their tenets ought not to disparage those, as well certain, as excellent and most useful sciences, pure mathematicks, any more than that the mathematicians, that follow the Ptolemaick, the Copernican, the Tychonian, or other systems of the world, write books to manifest one another's paralogisms in astronomical matters: and therefore (to proceed to what I was about to say) it cannot but be a satisfaction to a wary man to consult sense about those things, that fall under the cognisance of it, and to examine by experiences, whether men have not been mistaken in their hypotheses and reasonings; and therefore the learned *Stevinus* himself (the chief of the modern writers of Hydrostaticks) thought fit, after the end of his *Hydrostatical Elements*, to add in an appendix some pragmatical examples, (as he calls them) that is, mechanical experiments (how cogent I now inquire not) to confirm the truth of his tenth proposition, to which he had, not far from the beginning of his book, annexed what he thinks a mathematical demonstration. And, about the very subjects we are now upon, the following paradoxes will discover so many mistakes of eminent writers, that pretend to have mathematically demonstrated what they teach, that it cannot but make wary naturalists (and it is chiefly to gratify such, that I publish this) be somewhat dissident of conclusions, whose proofs they do not well understand. And it cannot but, to such, be of great satisfaction to find the things, that are taught them, verified by the visible testimony of nature herself. The importance of this subject, and the frequent occasion I have to make use of this kind of apology, will, I hope, procure me the reader's pardon, if I have insisted somewhat long upon it.

AFTER what has been hitherto discoursed, it will be easy for me to give an account, why I premise these hydrostatical paradoxes to the rest of the Appendix, wherewith they are * now published: for since a great part of my work, in that Appendix, was to be a further explication of some things delivered in the book it is subjoined to, and the vindication of them from invalid objections; and since I have generally observed, that the objections, that have been, either publicly or privately, made against the explications and reasonings contained in that book, were wont to proceed from unacquaintedness, either with the true notion of the weight and spring of the air, as I maintain them, or with the principles and theorems of Hydrostaticks, or else from erroneous conceits about them; I thought it would much conduce to both

* An account of this passage also may be had from the Publisher's Advertisement to the Reader.

the forementioned ends of my Appendix, if I cleared up that doctrine, to which my experiments and reasonings have been all along consonant; and whose being either not known, or misunderstood, seems to have occasioned the objections, that have been hitherto made against the hypotheses I have proposed, or the explications I have thence given. And however, since the proofs, I offer for my opinions, are for the most part drawn from experiments new and easy, and that my aim is but to discover truths, or make them out by clearer explications, without supposing, like those I dissent from, any thing, that is either precarious, or scarce, if at all, intelligible; I hope, that if I should not prove happy enough to reach my ends, yet the ingenious and equitable reader will approve my design, and be advantaged by my experiments. Of which some of the chiefest, and some of the most difficult, having been seen (divers of them more than once) by the Royal Society itself, or by inquisitive members of it; it will, I presume, be but a reasonable request, if the reader, that shall have the curiosity to try them over again, be desired not to be hasty in distrusting the matters of fact, in case he should not be able at first to make every thing succeed according to expectation. For, as easy as I have endeavoured to make these experiments, yet I dare not promise myself, that they will all of them be privileged from the fate, whereto I have observed other physico-mathematical ones to be not seldom obnoxious, from some unheeded physical circumstance, by which those, that are not acquainted with the subtleties of nature, or, at least for the time, do not sufficiently consider them, are apt to be imposed upon.

THIS advertisement will, perhaps, be best illustrated and recommended by an instance; and therefore I shall subjoin one, that will possibly seem somewhat odd.

It has been taken notice of by two or three ingenious modern mathematicians, and I have had occasion to make it out by particular experiments, that warm water is lighter *in specie*, than cold; whence it has been deduced, that wax, and other bodies, very near equiponderant with common water, will swim in that which is cold, and sink in that which is hot, or luke-warm. Which experiment, though as it may be (and perhaps it has been) tried, I readily allow to be agreeable to the known laws of the Hydrostaticks, yet I have sometimes undertaken, that the trial should have a quite contrary effect. To that purpose, having taken some yellow bees-wax, which was formed into a pellet of the bigness of a cherry, and, by the help of a little lead, was made so near equiponderate to cold water, that, being but a very little heavier, a very small diminution of its weight would make it emerge, I removed it out of the very cold water into some, that had been purposely made lukewarm (or a little more than so) where it quickly, somewhat to the wonder of the lookers on, appeared to swim on the top of the water. And that it might not be suspected, that it was supported by any visible bubbles, which I have observed, in some cases, to buoy up even heavy bodies, and deceive the unskilful, or unattentive; I briskly enough ducked the bullet two or three times under water to throw them off, notwithstanding which it constantly returned to float; and yet, being removed again into the same cold water it had been taken out of, and ducked as before, to free it from adherent bubbles, it lay quietly at the bottom, and, though raised several times to the upper part of the water, would immediately subside to the very lowest. Now that, which invited me to promise an experiment, which seems to contradict the principles of the Hydrostaticks, was not any distrust of those principles themselves, but a conjecture, that as by warmth the water would be made a little lighter *in specie* than it was before; so, by the same warmth, the spirituous and more agitable parts of the wax, whose texture is loose enough, would be somewhat (though not visibly) expanded, and would by that expansion gain a greater advantage towards floating, than the increased lightness
of

of the water would give it disposition to sink. And I confirmed this conjecture by a farther experiment, which at first was itself somewhat surprizing to the beholders. For when the wax was first taken out of the cold water, and immediately immersed in the warm, it would readily enough sink; and being (with a quill or a knife) raised to the top of the water, it would again fall down, but more slowly than at the beginning; and after some few minutes, if it were rais'd to the upper parts of the water, it would remain afloat. (And I have known it, when it had remained a while longer at the bottom, so to emerge, that if I were sure no unheeded bubbles had been newly generated, and held it up, it might be said to emerge of its own accord) as on the other side, being put into the cold water, as soon as ever it was taken out of the warm, it would at the very first float, and being then knocked downwards, it would, readily enough, regain the upper part of the water: but if I continued to send it downwards about six or seven times (more or fewer) successively, it would emerge every time more slowly than other, and at length not emerge at all, even when I tried it in water made heavy, by being highly in frigidated with salt and snow placed about the glass. Which phenomena I had thought it reasonable to expect, because I presumed, that the wax, being removed immediately out of the warm water into the cold, must require some time to lose the adventitious expansion, which the warmth had given it, and must be deprived of it by degrees, by the coldness of the water, into which the wax was transferred. As, on the other side, there must be some time necessary for so little a warmth, as that of the tepid (or little more than tepid) water, to give the wax that addition of dimensions, (which also it must receive by degrees) that was necessary, in spite of the rarefaction of the water, to make it float. I might add, that these trials were repeated, for the main, with more bullets of wax than one, and that they succeeded far otherwise, when, instead of a piece of wax, we employed a poised glass-bubble, in which the temperature could make either no change at all, or no considerable change of dimensions. And to these I might add other circumstances, if I did not remember, that I mention these trials but occasionally, and to make the caution, formerly recommended to the reader, appear not to be impertinent; since a hydrostatical experiment, true in itself, may easily miscarry by overlooking such circumstances, as it is not easy to be aware of.

BUT, by this advertisement, I would by no means divert men from being diffident of hydrostatical traditions and experiments. For, besides the many erroneous opinions, there are matters of fact, whose truth, though not questioned, but built upon, I think ought to be brought to trial. For, even whilst I was concluding this preface, I found, that divers, even of the moderns, and particularly a very learned man, that has lately written of Hydrostaticks, have much troubled themselves to render a reason, why, since, according to their doctrine, water weighs not in water, wooden vessels, though of a substance lighter than water, being by leaks, or otherwise, fill'd with water, should sink and remain at the bottom of the water: whereas, judging this phenomenon disagreeable to what I look upon as the laws of the Hydrostaticks, I was confirmed in that opinion, by having had the curiosity to make some trials of it, with four or five vessels of differing shapes and sizes, whereof two were of wax; which, though a matter but very little lighter than water, I could not sink, or keep sunk by pouring water into them, or suffering them to fill themselves at leaks made near the bottom: and if they were depressed by force or weights, they, as also the wooden vessels, would, upon the removal of the impediment, (and sometimes with the cavity upwards) emerge. And I am the more solicitous to have things in the Hydrostaticks duly ascertained, because the weighing of bodies in liquors may hereafter appear to be one of the general ways I have employed, and would recommend, for the examining of almost all sorts of tangible bodies.

HYDROSTATICAL PARADOXES,

MADE OUT BY

NEW EXPERIMENTS,

Presented to the ROYAL SOCIETY, (the Lord Viscount Brouncker
being then President) May 1664.

MY LORD,

TO obey the orders of the Society, that forbid the making of prefaces and apologies, in accounts of the nature of that, which you expect from me; I shall, without any further preamble, begin with taking notice, that upon perusal of Monsieur *Pascal's* small French book, which was put into my hands, I find it to consist of two distinct treatises; the one, of *the Æquilibrium* of liquors, as he calls it; and the other, of *the weight of the mass of the Air*.

As for this latter, (which I shall mention first, because I can in very few words dispatch the little I have to say of it) though it be an ingenious discourse, and contains things, which if they had been published at the time, when it is said to have been written, would probably have been very welcome to the curious; yet I have very little else to say of it in this place, in regard that, since that time, such kind of experiments have been so prosecuted, that I presume it is needless, and would not be acceptable to repeat, what Monsieur *Pascal* has written, in this Society, which has seen the same truths, and divers others of the like nature, more clearly made out by experiments, which could not be made by Monsieur *Pascal*, and those other learned men, that wanted the advantage of such engines and instruments, as have in this place been frequently made use of.

WHEREFORE, having already at a former meeting given you, by word of mouth, an account of Monsieur *Pascal's* ingenious invention, of a pair of bellows without vent, to measure the various pressure of the atmosphere; I remember nothing else, that needs hinder me from proceeding to the other part of his book, *The Treatise of the Æquilibrium of Liquors*.

THIS I find so short, and so worthy of the author, that to give you all, that I judge worth taking notice of in it, would oblige me to transcribe almost the whole tract; and therefore I shall rather invite you to read the whole, than divert you from the design by culling out any part of it; yet, if you will not be satisfied without something of more particular, I shall be obliged to tell you, that the discourse consisting partly of conclusions, and partly of experiments, the former seemed to me to be almost all of them (there being but few that I doubt of) consonant to the principles and laws of the Hydrostaticks. But as for the latter, the experimental proofs he offers of his opinions are such, that, I confess, I have no mind to make use of them.

AND the reasons, why, notwithstanding that I like most of Monsieur *Pascal's* assertions, I decline employing his way of proving them, are principally these:

FIRST, Because though the experiments he mentions be delivered in such a manner, as is usual in mentioning matters of fact; yet I remember not, that he expressly says, that he actually tried them, and therefore he might possibly have set them down, as

things, that *must* happen, upon a just confidence, that he was not mistaken in his ratiocinations. And of the reasonableness of this doubt of mine, I shall ere long have occasion to give an instance.

SECONDLY, Whether or no Monsieur *Pascal* ever made these experiments himself, he does not seem to have been very desirous, that others should make them after him. For he supposes the phenomena he builds upon to be produced fifteen or twenty foot under water. And one of them requires, that a man should sit there with the end of a tube leaning upon his thigh; but he neither teaches us, how a man shall be enabled to continue under water, nor how, in a great cistern full of water, twenty foot deep, the experimenter shall be able to discern the alterations, that happen to mercury, and other bodies at the bottom.

AND thirdly, These experiments require not only tubes twenty foot long, and a great vessel of, at least, as many feet in depth, which will not in this country be easily procured; but they require brass cylinders, or plugs, made with an exactness, that, though easily supposed by a mathematician, will scarce be found obtainable from a tradesman.

THESE difficulties making the experiments proposed by Monsieur *Pascal* more ingenious than practicable, I was induced, on this occasion, to bethink myself of a far more expeditious way to make out, not only most of the conclusions, wherein we agree, but others, that he mentions not; and this with so much more ease and clearness, that not only this illustrious assembly, but persons, no more than moderately versed in the vulgar principles of the Hydrostaticks, may easily enough apprehend, what is designed to be delivered, if they will but bring with them a due attention, and minds disposed to prefer reason and experience to vulgar opinions and authors: which last clause I annex, because the following discourse, pretending to confute several of those, challenges a right to except against their authority.

It not being my present task to deliver the elements, or a body of Hydrostaticks, but only ten or twelve paradoxes, which I conceive to be proveable by this new way of making them out; I shall, to avoid confusion, deliver them in as many distinct propositions: after each of which, I shall endeavour in a proof, or an explication, to shew, both that it is true, and why it ought to be so. To all these I shall, to avoid needless repetitions, premise a word or two by way of postulatum, or lemma.

AND because I remember, to what assembly I address this discourse, I shall make use of no other, than an easy supposition I met with, in a short paper (about a mercurial phenomenon) brought in a year or two since to this learned Society, by a deservedly famous member of it*: for though his supposal be made upon occasion of an experiment of another nature, than any of the ensuing, it may be easily accommodated to my present purpose.

THIS postulatum, or lemma, consists of three parts; the first of them more, and the two last less principal.

SUPPOSE we then, first, that if a pipe open at both ends, and held perpendicular to the horizon, have the lower of them under water, there passes an imaginary plane or surface, which touching that orifice, is parallel to the horizon, and consequently parallel, as to sense, to the upper surface of the water; and this being but a help to the imagination, will readily be granted.

* That excellent mathematician, the learned Dr. *Wallis*, Savilian Professor of Geometry.

SECONDLY, To this it will be consonant, that each part of this designable surface will be as much, and no more pressed, as any other equal part of it, by the water that is perpendicularly incumbent on it. For the water, or other fluid, being supposed to be of an homogeneous substance, as to gravity, and being of an equal height upon all the parts of the imaginary surface; there is no reason, why one part should be more pressed by a perpendicular pillar of that incumbent fluid, than any other equal part of the same surface by another perpendicularly incumbent pillar of the same, or equal basis and height, as well as of the same liquor.

BUT thirdly, Though whilst our imaginary surface is equally pressed upon in all parts of it, the liquor must retain its former position; yet, if any one part comes to have a greater weight incumbent on it, than there is upon the rest, that part must be displaced, or depressed, as it happens, when a stone, or other body heavier than water, sinks in water. For wherever such a body happens to be underneath the water, that part of the imaginary plane, that is contiguous to the lower part of the stone, having on it a greater weight, than other parts of the same surface, must needs give way; and this will be done successively, till the stone arrive at the bottom. And if, on the other side, any part of the imaginary surface be less pressed upon than all the rest, it will, by the greater pressure on the other parts of the surface, be impelled upwards, till it have attained a height, at which the pressure (of the raised water, and the lighter or floating body, if any there be, that leans upon it and gravitates together with it upon the subjacent part of the imaginary surface) will be equal to that, which bears upon the other parts of the same surface.

AND because this seems to be the likeliest thing to be questioned in our † assumption, though he, that considers it attentively, will easily enough be induced to grant it; yet I shall here endeavour to evince it experimentally, and that by no other way of proof, than the same I employ all along this present discourse.

TAKE then a cylindrical glass pipe, of a convenient bore, open at both ends; let the tube be steadily held perpendicular to the horizon, the lower end of it being two or three inches beneath the surface of a convenient quantity of water, which ought not to fill the glass vessel, that contains it. The pipe being held in this posture, it is manifest, that the water within the pipe will be almost in a level with the surface of the water without the pipe, because the external and internal water (as I am wont for brevity's sake to call them) have free intercourse with one another, by the open orifice of the immersed end of the pipe; yet I thought fit to insert the word *almost*, because, if the pipe be any thing slender, the surface of the water in it will always be somewhat higher than that of the water without it, for reasons, that it is not so necessary we should now inquire after, as it is, that we should here desire to have this taken notice of once for all; that mistakes may be avoided without a troublesome repetition of the difference in heights of the surface of liquors within pipes and without them, in case they be any thing slender.

THE pipe being held in the newly-mentioned posture, if you gently pour a convenient quantity of oil upon the external water, you shall see, that as the oil grows higher and higher above the surface of that water, the water within it will rise higher and higher, and continue to do so, as long as you continue to pour on oil; of which

† This Experiment, and the Explication of it, if to some they should here seem somewhat obscure, will be easily understood by the Figures and Explications belonging to the first ensuing paradox.

the reason seems manifestly to be this; that in the imaginary plane, that passes by the orifice of the immersed end of the pipe, all that is not within the compass of the orifice, is exposed to an additional pressure from the weight of the oil which swims upon the water, and that pressure must still be increased, as there is more and more oil poured on: whereas a circular part of the imaginary plane, equal to the orifice of the glass, is by the sides of the pipe fenced from the immediate pressure of the oil; so that all those other parts of the water, being far more pressed, than that part, which is comprehended within the cavity of the tube, and consequently the pressed parts of the external water are, by the equal gravitation of the oil upon the parts of the external water, impelled up into the cavity of the pipe, where they find less resistance than any where else, till they arrive at such a height, that the cylinder of water within the pipe does as much gravitate upon the subjacent part of the imaginary surface, as the water and oil together do upon every other equal part of the same surface or plane.

BUT as well the former lemma, as this experiment, will be sufficiently both cleared and confirmed by the following explications; to which I should for that reason forthwith proceed, were it not, that, since divers passages of the following treatise suppose the air to be a body not devoid of weight, which yet divers learned adherents to the Peripatetick philosophy do resolutely deny, it seems requisite to premise something for the proof of this truth.

AND though I think the arguments we have employed to that purpose already, do strongly evince it; yet, if I may be allowed to anticipate one of my own experiments of the Appendix, I shall give an instance of the weight of the air, not liable so much as to those invalid objections, which some of the Aristotelians have made against those proofs, wherewith we have been so happy, as to satisfy the learnedest even of our professed adversaries.

WE caused then to be blown at the flame of a lamp a bubble of glass, (of about the bigness of a small hen-egg) which, that it might be light enough to be weighed in exact scales, ought to be of no greater thickness than is judged necessary to keep it from being (when sealed up with none but very much expanded air in it) broken by the pressure of the ambient atmosphere. This bubble was (like a pear with its stem) furnished with a very slender pipe of glass, at which it was blown, that it might be readily sealed up; and then, (the air within it being by the flame of the lamp gradually rarified, as much as conveniently could be) whilst the body of the bubble was exceeding hot, the newly-mentioned stem was nimbly put into the middle of the flame; where, by reason of its slenderness, the glass, which was exceeding thin, was immediately melted, whereby the bubble was hermetically sealed up. This glass being permitted leisurely to cool, I could afterwards keep it by me an hour, or a day, or a week, or longer, if I thought fit; and when I had a mind to shew the experiment, I put it in one of the scales of an exact balance, that would turn, perhaps, with the thirtieth, or fiftieth, or a less part of a grain; and having carefully counterpoised it, I then warily broke off the sealed end, placing a sheet of paper just under the scale, to receive the fragments of the glass; and putting in again those fragments, that scale, wherein the glass was, would considerably preponderate; which it must do upon the account of the weight of air, there being no other cause, either needful, or justly assignable, but the weight of the air that rushed into the cavity of the glass, as finding less resistance there than elsewhere, by reason that the included air had its spring much weakened by its great expansion.

THIS experiment I many times tried, sometimes before some Virtuosi, and sometimes before others; who all allowed it to be conclusive. For here it could not be objected, as against the weighing of air in a bladder, (which objections yet I could easily answer, if it were now proper) that the air, which ponderates, is stuffed with the effluvia of him, that blows the bladder, and (besides that) is not air in its natural state, but violently compressed. For here it is the free air, and in its wonted laxity, that makes the glass preponderate.

AND that there is a great ingress of the external air, is evident by these three phenomena. The one, that if you lend an attentive ear, you shall plainly hear a kind of whistling noise to be made by the external air, as it rushes violently in upon the breaking of the glass; the other, that the rarefaction of the air sealed up in the bubble being very great, there is a great deal of space left for the ambient air to fill upon its admission; and the greatness of this rarefaction may be guessed at, both by the breaking of such bubbles now and then by the pressure of the external air, which is not competently assisted by the internal to resist; and also by the third phenomenon I intended to take notice of, namely, That, if, instead of breaking off the sealed end of the glass in the air, you break it under water, that liquor will, by the pressure of the atmosphere, be forced to spring up like an artificial fountain into the cavity of the bubble, and fill about three quarters of it. By which last circumstance I gather, that the weight of the air is more considerable, than even many, who admit the air to have weight, seem to imagine. For we must not suppose, that all the air contained in the bubble, when broken, weighs no more, than the weight requisite, in the opposite scale, to reduce the balance to an æquilibrium; since this additional weight is only that of the air, that intrudes on the breaking of the glass; which air, by the observations newly mentioned to have been made with water, appears to be but about three quarters of the whole air contained in the broken bubble; and yet, according both to our estimate, and that of divers Virtuosi, and some of them eminent mathematicians, when the capacity of the bubble was short of two cubical inches, (and so proportionably in other glasses) the nice balance we used, manifested the newly-admitted air to amount to, sometimes, near half a grain, and sometimes beyond it.

AND because one of the last experiments that I made to this purpose, with sealed bubbles, was none of the least accurate, I shall conclude this subject with the following account of it:

A THIN glass bubble, blown at the flame of a lamp, and hermetically sealed, when the contained air was exceedingly rarified, was counterpoised in a nice pair of scales; and then the sealed *apex* being broken off, and put again into the same scale, the weight appeared to be increased by the re-admitted air, a pretty deal above $\frac{1}{16}$ ths, and consequently very near, if not full $\frac{1}{4}$ of a grain. Lastly, having by some slight (for it is no very easy matter) filled it with common water, we weighed the glass and water together, and found the latter, besides the former, to amount to nine hundred and six grains. So that supposing, according to our former estimate, countenanced by some trials, that the re-admitted air, which amounted to $\frac{1}{4}$ of a grain, filled but $\frac{1}{4}$ of the whole cavity of the bubble, the air that was in it, when sealed, possessing one quarter of that cavity, the whole air contained in the bubble may be reasonably presumed to weigh a whole grain; in which case we might conclude (abstracting from some little niceties, not so fit to be taken notice of here, as elsewhere) that the water in our experiment weighed very little more, than nine hundred times as much as an equal quantity of air. And therefore, though we allow, that in an experiment so diligently made as this was, the air pre-existent in the bubble did not adequately possess

possess so much as a fourth part, but about a fifth, or a sixth of its cavity, the air will yet appear so heavy, that this experiment will agree well with those others, recorded in another treatise, wherein we assigned (*numero rotundo*) a thousand to one, for the proportion wherein the specifick gravity of water exceeds that of air.

P A R A D O X I.

That in water, and other fluids, the lower parts are pressed by the upper.

PROVIDE a glass-vessel of a convenient height and breadth, A, B, C, D, filled with water almost to the top; then take a glass-pipe, open at both ends, cylindrical, and of a small bore, (as about the eighth, or sixth part of an inch in diameter.) Put the lower end of this pipe into clear oil, or spirit of turpentine; and having, by suction, raised the liquor to what part of the pipe you think fit, as soon as it is there, you must, very nimbly removing your lips, stop the upper orifice with the pulp of your finger, that the raised liquor may not fall back again: then, taking the pipe, and that liquor out of the oil of turpentine, place it perpendicularly in the glass of water, so as that the surface of the oil in the pipe be somewhat higher than that of the water without the pipe; and having so done, though you take off your finger from the upper orifice of the pipe, the oil will not fall down at the lower orifice, though that be open, but will remain suspended at the same height, or near thereabouts, that it rested at before.

Now oil of turpentine, being a heavy fluid, does, as such, tend downwards; and not being stopped by the glass itself, whose lower orifice is left open, it would certainly fall down through the pipe, if it were not kept suspended by the pressure (upwards) of the water beneath it; there appearing no other cause, to which the effect can reasonably be ascribed, and this being sufficient to give an account of it, as we shall presently see. For that it is not any contrariety in nature, betwixt the oil and the water, as liquors, that will not mingle, is evident from hence; that if you had removed your finger, when the pipe was not so deeply immersed in the glass, but that the surface of the oil in the pipe was an inch or two more elevated above that of the water in the glass, than in our present case we suppose it to be; the oil, notwithstanding its presumed contrariety to water, would have freely subsided in the pipe, till it had attained an equipollency of pressure with the external water.

THE reason, therefore, of the phenomenon seems to be plainly this: Supposing the imaginary surface, on which the extremity Q and the pipe P Q leans, to be G H. If that part of the surface, on which the oil leans at Q, be as much, and no more charged, or pressed upon by the weight of the incumbent cylinder of oil Q X, than the other parts of the same imaginary surface G H are by the water incumbent on them, there is no reason, why that part at Q should be displaced, either by being depressed by the weight of the cylinder of oil X Q, or raised by the equal pressure of water upon the other parts of the superficies G H.

AND that this æquilibrium, betwixt the oil and the water, is the true cause of the phenomenon, may be confirmed by observing what happens, if the altitude of either of the two liquors be altered in relation to the other.

AND, first, we have already taken notice, that if the cylinder of oil reach, in the pipe, much higher than that of the surface of the water, the oil will descend: of which the reason is, because, the designable surface G H being more charged at Q than

Q than any where else, the part Q, being unable to resist so great a pressure, must necessarily be thrust out of place by the descending oil.

SECONDLY, This subsiding will continue but till the surface of the oil in the pipe be fallen almost as low, as that of the water without the pipe; because then, and not before, the parts at Q are but as much pressed by the oil, as the other parts of the surface G H are by the water, that leans upon them.

THIRDLY, It is a concluding circumstance to our present purpose, that if, the oil and water being in an æquilibrium, you gently lift up the pipe, as from Q to S, the depth of the water being lessened, the oil in the pipe will grow preponderant, and therefore will fall out in drops or globules; which, by the greater specifick gravity of the water, will be buoyed up to the top of the liquor, and there float: and still, as you lift up the pipe higher and higher towards the surface L M, more and more of the oil will run out. But if you stop the pipe any where in its ascent, as at S, the effluxion of the oil will likewise be stopped. And at the imaginary superficies I K, as by reason of the shallowness of the water from L to J, or M to K, the pressure of the water upon the other parts of the surface is not near so great, as it was upon the surface G H, where the water had a greater depth; so, by reason of the proportionate effluxion of the oil, whilst the pipe was lifted up from Q to S, the remaining cylinder of oil, incumbent on S, is not able to press that part of the superficies I K more strongly, than the other parts of the same superficies are pressed by the water incumbent on them. And if the pipe be lifted up, till the lower orifice be almost raised to V, that is, almost as high as the uppermost surface of the water L M, so much of the oil will, for the reason already given, run out, that there will scarce be any left in the pipe T V.

FOURTHLY, But if, when the pipe rests at the surface G H, where the oil is in an æquilibrium with the water, you should, instead of lifting it from Q to S, thrust it down from Q to O; then the external water would not only sustain the oil, but make it ascend in the pipe to a height equal to the distance E G; and so the pipe will contain, besides a longer cylinder of oil Æ W, a shorter one of water Æ O. For the pipe being transferred from the position P Q, to the position O N, there is a new imaginary surface E F, that passes by the lower orifice of the pipe. Now the part of this surface at O will not, by the incumbent oil alone, be pressed as much as the other parts of the same surface are by the incumbent water. For the oil alone was but in æquilibrium with the water, when it was no deeper than L G, or H M; so that the other parts of the superficies E F being more pressed upon by the water, than the part at O by the oil, the oil must give place, and be buoyed up by the water, (which, if it were not for the weight of the oil, would be impelled up into the pipe full as high as the surface of the external water) till the pressure of the admitted water O Æ, and the cylinder of oil Æ W, do both together gravitate as much upon the part O, as the rest of the incumbent water does upon the other parts of the same superficies E F.

FIFTHLY, and lastly, It is very agreeable to what has been delivered, touching the æquilibrium of the oil and water in the pipe P Q, that the surface X, of the oil in the pipe, will not be of the same level with L M, that of the external water, but a little higher than it. For though the slenderness of the pipe do somewhat contribute to this effect, yet there would be an inequality, though not so great, betwixt these surfaces, upon this account; that oil of turpentine being *in specie*, (as they speak in the schools) that is, bulk for bulk, a lighter liquor than water, it is requisite, that the height of it, incumbent on the part Q, be greater than that of the water on the other parts of the same surface G H, to make the pressure of the oil, on the part it
leans

leans upon, equal to the pressure of the water on the other parts of the surface. And if the inequality were greater betwixt the specific gravities of these two liquors, the inequalities betwixt the surface X and the surface L M would be also greater; as may be tried by substituting, for common water, oil of tartar *per deliquium*, which is a saline liquor much heavier than it. And that, in case the pipe contain not a lighter liquor than the external fluid, the surface of the liquor in the pipe will not be higher, than that of the liquor without it, we shall by and by have opportunity to manifest by experience.

FROM what has been hitherto shewn, we may safely infer the proposition, upon whose occasion all this has been delivered. For since the oil, in a pipe open at both ends, may be kept suspended in any part under water, as at Q, because it is there in an æquilibrium with the external water; and since, being lifted up in the water, as from Q to S, the oil can no longer be kept suspended, but, by its own gravity, will run out: and since, in a word, the deeper the water is, the greater weight and pressure is required in the cylinder of oil, to be able to countervail the pressure of the water, and keep itself from being lifted up thereby; there seems no cause to doubt, but that the parts of the water incumbent on the superficies G H do more press that superficies, than the parts of the water contiguous to the superficies J K do press that; and consequently, that the parts of the water, that are under the uppermost surface of it, are pressed by those of the same fluid, that are directly over them. As we saw also, that the upper parts of the oil, whilst the pipe was in raising from Q to S, depressed the lower so much, as to force them quite out of the pipe; there being, in these cases, no reason, why the lowermost parts of a liquor should press more, or have a stronger endeavour against any other liquor (or any other body) the higher the liquor incumbent reaches, if these inferior parts derived their pressure only from their own particular gravity, (which is no greater, than that of the other homogeneous parts of the liquor:) and therefore they must derive the great force, wherewith they press, from the weight of the incumbent parts, which, consequently, must be allowed to press upon them.

BUT, before I proceed to the following propositions, it will not be amiss to mention here, once for all, a few advertisements, to avoid the necessity of repeating the same things in the sequel of the discourse.

AND first, What is here said of the pressure of the parts of water upon one another, and the other affections, that we shall attribute to it, in the following paper, are to be applied to heavy fluids in general, unless there shall appear some particular cause of excepting some of them in particular cases.

SECONDLY, Whereas I lately intimated, that the inequality betwixt the surfaces of the oil in the pipe, and of the external water, was in part to be ascribed to the slenderness of the pipe to be employed in these experiments; I did it for this cause, that, whatever the reason of it be, (which we need not here inquire after) we are assured by experience, as we have elsewhere shewn, that, when glass-pipes come to be slender, water, and many other liquors (though not quicksilver) will have within them a higher surface, than that of the same liquor without them; and this inequality of surfaces (as far as we have yet tried) increases with the slenderness of the pipe. But this, as to our present experiment, is a matter of so little moment, that it may suffice to have intimated, that we did not oversee it.

THIRDLY, Wherefore, notwithstanding this little inconvenience of slender glasses, we think it expedient to employ such in the following experiments, because we found, that in those of a wide bore, upon such little inequalities of pressure, as are not easily to be avoided, the oil and water will pass by one another in the cavity of the

the pipe, and so spoil the experiment, which requires, that the oil within the pipe be kept in an intire and distinct body.

FOURTHLY, Common oil and water, or any other two liquors, that will not mingle, may serve the turn in most of these experiments; but we rather chuse oil of turpentine, because it is light and thin, clear and colourless, and may be easily had in quantities, and is not so apt to spot one's clothes, or obstinately to adhere to the porous bodies it chances to fall on, as common, and other expressed oils. And for their sakes to whom the odour is offensive, we presently correct it, by mingling with it a convenient quantity of oil of rhodium, or some other chymical oil, that is odoriferous.

FIFTHLY, Oil of turpentine, though it be not reckoned among the saline menstruums, will yet (as we elsewhere note) work upon copper, and so by digesting it upon crude filings of that metal, we obtain a deep green liquor, which may be made use of instead of the limpid oil, to make the distinction of the liquors more conspicuous.

SIXTHLY, And for the same purpose we often use, instead of clear water, a strong decoction of brazil, or log-wood, or else red ink itself: I say, a strong decoction, because unless the liquor be so deeply tinged, as to appear opacous in the glass, when it comes into the slender pipe, its colour will be so diluted, as to be scarce discernible.

SEVENTHLY, In the shape of the glass-vessel, we need not be curious; though that of a wide-mouthed jar, expressed in the scheme, be for some uses more convenient than other shapes. The depth of these glasses, and the length of the pipes, must be determined by the experiments, about which one means to employ them. To make out the first paradox already proved, a glass of about five or six inches deep, and a pipe about as many inches long, will serve the turn: but for some others of the following experiments, tall cylindrical glasses will be requisite; and for some, broad ones likewise will be expedient.

EIGHTHLY, One must not be discouraged by not being able, at the first or second time, to suck up oil of turpentine to the due height, and stop it with one's finger from relapsing; but one must try again, and again; especially since many trials of this kind may be made in a few minutes; and for beginners it is a safe and good, though not the shortest way, to suck up rather more liquor than one judges will be needful; because having filled the pipe to that height, you may, by letting in the air warily and slowly between the orifice of the glass and the pulp of your finger, suffer so much liquor to run out of the pipe, as will reduce it to the height you desire; and there, by close stopping the orifice with your finger, you may keep it suspended as long as you please, and immerse it into any heterogeneous liquor, and take it out again at pleasure without spilling any of it. By which slight expedient alone, I can decline several difficulties, and do many things, which, according to Monsieur Pascal's way, require a great deal of trouble and apparatus to be performed.

LASTLY, in such experiments, where it may be of use, that there be a considerable disparity betwixt the two unmingled liquors, we may (as is above intimated) instead of fair water, employ *oleum tartari per deliquium*, and tinge it with brazil or cochineel; from either of which, but especially from the latter, it will obtain an exceeding deep redness. And where one would avoid strong scents and oiliness, he may, if he will be at the charge, employ oil of tartar *per deliquium*, instead of fair water; and highly rectified spirit of wine, instead of oil of turpentine. For these two liquors, though they will both readily mingle with water, will not with one another: and if a great

quantity of some other liquor be to be substituted for simple water, when these chymical liquors are not to be had in plenty, one may imploy (as we have done) a very strong solution made of sea-salt, and filtered through cap-paper: this brine being near about as limpid as common water, and far heavier than it. And for a curiosity, we have added to the two lately mentioned liquors (oil of tartar, and spirit of wine) some oil of turpentine, and thereby had three liquors of different gravities, which will not by shaking be brought so to mingle, as not quickly to part again, and retire each within its own surface; and by thrusting a pipe with water in the bottom of it (placing also one's finger upon the upper orifice) beneath the surface of the lowermost of these liquors, and by opportunely raising or depressing it, one may somewhat vary the experiment in a way not unpleasant, but explicable upon the same grounds with the rest of the phænomena mentioned in this discourse.

P A R A D O X II.

That a lighter fluid may gravitate or weigh upon a heavier.

I KNOW that this is contrary to the common opinion, not only of the schools, but even of divers hodiern mathematicians, and writers of Hydrostaticks, some of whom have absolutely rejected this paradox, though they do but doubt of the truth of the former.

BUT when I consider, that whether the cause of gravity be the pulsion of any superiour substance, or the magnetical attraction of the earth, or whatever else it be, there is in all heavy bodies, as such, a constant tendency towards the center, or lowermost parts of the earth; I do not see, why that tendency or endeavour should be destroyed by the interposition of any other heavy body; though what would otherwise be the effect of that endeavour, namely, an approach towards the center, may be hindered by another body, which being heavier than it, obtains by its greater gravity a lower place; but then the lighter body tending downwards, must needs press upon the heavier, that stands in its way, and must, together with that heavier, press upon whatever body it is, that supports them both, with a weight consisting of the united gravities of the more, and the less heavy body.

BUT that, which keeps learned men from acknowledging this truth, seems to be this, that a lighter liquor (or other body) being environed with a heavier, will not fall down, but emerge to the top: whence they conclude, that, in such cases, it is not to be considered as a heavy, but as a light body.

BUT to this I answer, that though in respect of the heavier liquor, the less heavy may, in some sense, be said to be light; yet notwithstanding that relative or comparative levity, it retains all its absolute gravity, tending downwards as strongly as before; though, by a contrary and more potent endeavour upwards of the contiguous liquor (whose lower parts, if less resisted, are pressed upwards by the higher, elsewhere incumbent; according to the doctrine partly delivered already, and partly to be cleared by the proof of the next proposition) its endeavour downward is so surmounted, that it is forcibly carried up. Thus when a piece of some light wood being held under water, is let go, and suffered to emerge, though it be buoyed up by the water, whose specific gravity is greater, yet even whilst it ascends it remains a heavy body; so that the aggregate of the water, and the ascending wood, weighs more than the water alone would do; and when it floats upon the upper part of the water, as

part

part of it is extant above the surface, so part of it is immersed beneath it, which confirms what we were saying, that a lighter body may gravitate upon a heavier.

AND thus there is little doubt to be made, but that if a man stand in one of the scales of a balance with a heavy stone tied to his hand, and hanging freely by his side, if then he lift that weight as high above his head as he can, notwithstanding that the stone's motion upwards makes it seem a light body, in respect of the man, whose body it leaves beneath it, yet it does not, either during its ascent or after, lose any thing of its connatural weight. For the man, that lifts it up, shall feel its tendency downwards to continue, though his force, being greater than that tendency, be able, notwithstanding that tendency, to carry it up: and when it is aloft, it will so press against his hand, as to offend, if not also to bruise it; and the stone, and the man, that supports it, will weigh no less in the scale he stands in, than if he did not at all support it, and they were both of them weighed apart.

LIKEWISE, if you put into one scale a wide-mouthed glass full of water, and a good quantity of powdered common salt; and into the other scale a counterpoise to them both; you may observe, that, though at the beginning the salt will manifestly lie at the bottom, and afterwards by degrees be so taken up into the body of the liquor, that not a grain will appear there; yet nevertheless (as far as I can judge by my experiments) the weight in that scale will not be diminished by the weight of as much salt as is incessantly either carried up, or supported by the restless motion of the dissolving corpuscles of the water; but both the one and the other, (allowing for what may evaporate) will concurrently gravitate upon the scale, that the glass containing them leans on.

BUT of this more elsewhere. Now to prove the proposition, by the new method, we have proposed to ourself, in this discourse:

TAKE a slender glass-pipe, and having sucked up into it fair water, to the height of three or four inches, stop nimblely the upper orifice with your finger, and immerse the lower into a glass full of oil of turpentine, till the surface of the oil in the vessel be somewhat higher than that of the water in the pipe: then removing your finger, though the pipe do thereby become open at both ends, the water will not fall down, being hindered by the pressure of the oil of turpentine, as will be obvious to them, that have attentively considered the explication of the former paradox; there being but this difference between this experiment and that there explained, that here the water is in the pipe, and the oil in the vessel, whereas there the oil was in the pipe, and the water in the vessel. And if you either pour more oil into the glass, or thrust the pipe deeper into the oil, you shall see that the water will be buoyed up towards the top of the pipe; that is, a heavier liquor will be lifted up by a lighter. And since, by the explication of the first proposition, it appears, that the reason, why the liquor is in this case raised in the pipe, is the gravity of the liquor that raises it, we must allow, that a lighter liquor *in specie* may by its gravity press against a heavier.

AND it agrees very well with our explication, both of this, and of the first experiment; that as there, the surface of the oil in the pipe was always higher than that of the water without it, because the oil being the lighter liquor, a greater height of it was required to make an æquilibrium; so in our present experiment the surface of the liquor in the pipe will always be lower than that of the oil without it. For in the imaginary plain E F, the cylinder of water J G, contained in the pipe J H, will, by reason of its greater gravity, press as much upon the part J, as the distilled oil (K E, J L) being a lighter liquor, can do upon the

See the second figure.

other parts of the same supposed plain E F, though the oil reached to a greater height above it.

THIS second paradox, we have hitherto been discoursing of, may be also proved by what we formerly delivered, to make out the truth of the third part of the lemma premised to these propositions.

BUT because this and the former paradox are of importance, not only in themselves, but to the rest of this treatise, and are likely, in most readers, to meet with indisposition enough to be received, I will subjoin in this place a couple of such experiments, as will not, I hope, be unacceptable, that I devised, the one to confirm this second paradox, and the other to prove the first.

SOME of the gentlemen now present may possibly remember, that about the end of the year, that preceded the two last, I brought into this place a certain new instrument of glass, whereby I made it appear, that the upper parts of water gravitate upon the lower; which I did, by sinking a body, that was already under water, by pouring more water upon it.

BUT that experiment belonging to other papers, I shall here substitute another performed by an instrument, which, though it makes not so fine a shew, may be more easily provided, and will as well as that other (though you were pleased to command that from me) serve to make out the same truth; which I shall apply myself to do, as soon as I have, by an improvement of the expedient I am to propose, made good my late promise of confirming the second paradox.

AND before I can well draw an argument from these experiments, for either of the propositions to be proved by them, I must briefly repeat what I have elsewhere delivered * already (on another occasion) touching the cause of the sinking of such bubbles; namely, that the bubble X consisting of glass, which is heavier *in specie* than water; and air, which is lighter *in specie* than water; and, if you please, also of water itself, which is of the same specifick gravity with water; as long as this whole aggregate of several bodies is lighter than an equal bulk of water, it will float; but in case it grows heavier than so much water, it must, according to the known laws of the hydrostaticks, necessarily sink, (being not otherwise supported.) Now when there is any competent pressure (whether produced by weight or otherwise) upon the water, in which this bubble is for the most part immersed, because the glass is a firm body, and the water, though a liquor, either suffers no compression, or but an inconsiderable one; the air included in the bubble, being a springy and very compressible body, will be compelled to shrink, and thereby possessing less room than it did before, the contiguous water will succeed in its place; which being a body above a thousand times heavier than air, the bubble will thereby become heavier than an equal bulk of water, and consequently will sink: but if that force or pressure be removed, the imprisoned air will, by its own spring, free itself from the intruding water; and the aggregate of bodies, that makes up the bubble, being thereby grown lighter than an equal bulk of water, the subsided bubble will presently emerge to the top.

THIS explication of the causes of the sinking of bubbles agrees in some things with the doctrine of the learned Jesuits Kircher and Schottus, and some other writers, in the account they give of those two experiments, that are commonly known by the name, the one of the Roman, the other of the Florentine experiments. But there are also particulars, wherein I (who have never a recourse to a *fuga vacui*) dissent from their doctrine: the principles, I go upon, having invited and assisted me to make that

* In certain notes upon some of the Physico-mechanical Experiments touching the air.

experiment, afford me some new phenomena, which agree not with their opinions, but do with mine: but I forbear to mention them here, because they belong to other papers; and for the same reason I omit some accession of ludicrous phenomena (as they call them) which I remember I have sometimes added to those, which our industrious authors have already deduced from those experiments.

THESE things being premised, I proceed to the confirmation of the second paradox, by the following experiment:

TAKE a long glass-pipe, sealed, or otherwise exactly stopped at one end, and open at the other; (whose orifice, if it be no wider than that it may be conveniently stopped with a man's thumb, the tube will be the fitter to exhibit some other phenomena.) Into this pipe pour such a quantity of common water, as that there may be a foot, or half a yard, or some other competent part left unfilled, for the use to be by and by mentioned. Then having poised a glass-bubble with a slender neck, in such a manner, as that, though it will keep at the top of the water, yet a very little addition of weight will suffice to sink it, put this bubble thus poised into the tube; where it will swim in the upper part of the water, as long as it is let alone; but if you gently pour oil of turpentine upon it, (I say gently, to avoid confounding the liquors) you will perceive, that, for a while, the bubble will continue where it was: but if you continue pouring on oil, till it have attained a sufficient height above the water, (which it will be easy to perceive, because those two liquors will keep themselves distinct) you shall see the bubble subside, till it fall to the bottom, and continue there as long as the oil remains at the height above the water.

THE reason of this phenomenon, according to our doctrine, is this, that the oil of turpentine, though a lighter liquor than water, yet gravitates upon the subjacent water, and by its pressure forces some of it into the cavity of the bubble at the open orifice of its neck, whereby the bubble, which was before but very little less heavy than an equal bulk of water, being by this accession made a little more heavy, must necessarily sink: and the cause of its submersion, namely the pressure of the oil, continuing, it must remain at the bottom.

AND to confirm this explication, I shall add, that in case, by inclining the tube or otherwise, you remove the cylinder of oil, or a competent part of it, (in case it were longer than was necessary) the bubble will again emerge to the top of the water (for, as for the oil, that is too light a liquor to buoy it up) which happens only, because the pressure of the oil upon the water being taken off, the air, by virtue of its own spring, is able to recover its former expansion, and reduce the bubble to be as light, as it was before.

AND now we may proceed to that other experiment, by which we lately promised to confirm the first paradox. And, in some regard, this following experiment has been preferred, as more strange, to that I have been reciting; for it seemed much less improbable, that, of two heterogeneous liquors, the inferior should be pressed upon by the incumbent, which, though lighter, kept in an intire body above it; than that, in water, which is a homogeneous liquor, and whose parts mingle most freely and exquisitely with one another, the upper part should press upon the lower; and that they will do so, may appear by the experiment it is now time to subjoin.

PROVIDE a long tube, and a poised bubble, as in the former experiment; then, having poured water into the tube, till it reach above five or six inches (for a determinate height is no way necessary) above the bottom, cast in the bubble, which will not only swim, but, if you thrust it down into the water, it will of itself emerge to the upper part of it. Wherefore take a slender wand, or a wire, or a slender glass-
pipe,

pipe, or any such body, that is long enough for your purpose, and, with it, having thrust the bubble beneath the surface of the water, pour water slowly into the tube, (whose cavity will not be near filled by the rod, or wire) till it have attained a competent height, (which, in my last trials, was about a foot, or half a yard above the bubble) and you shall see, that the bubble, which before endeavoured to emerge, will, by the additional weight of the incumbent water, be depressed to the bottom of the tube. After which you may safely remove the wire, or other body, that kept it from rising. For, as the weight of the incumbent water was that, which made it sink, so, that weight continuing on it, the bubble will continue at the bottom.

BUT yet it is not without cause, that we employ a wire, or some such thing, in this experiment, though we affirm it to be only the weight of the incumbent water, that makes the bubble sink. For if you should pour water into the tube to the height lately mentioned, or even to a greater, if you did not make use of the wire, it would not serve the turn; because that, as fast as you pour in the water, the bubble, being left to itself, will rise together with it; and so, keeping always near the upper part of the water, it will never suffer the liquor to be so high above it, as it must be, before it can depress it. But to confirm, that it is the weight of the superiour water, that sinks the bubble, and keeps it at the bottom; if you take out of the tube a competent quantity of that liquor, and so take off the pressure of it from the bubble, this will presently, without any other help, begin to swim, and regain the upper part of the water; whence it may at pleasure be precipitated, by pouring back into the tube the water, that was taken out of it. And these confirmations, added to the former proofs of the first and second paradoxes, being, we conceive, sufficient to satisfy impartial readers of the truth of them, we should presently advance to the next proposition, if we did not think fit to interpose here a scholium.

SCHOLIUM.

IT may, perchance, be wondered at, why, since we lately mentioned our having made some trials with oil of tartar *per deliquium*, we did not, in the present experiment, instead of fair water, make use of that, it being a very much heavier liquor, and (though it may be incorporated with expressed oils) unmingeable, in such trials, with oil of turpentine. But to this I answer; that, even in such slender pipes, as those made use of about the first experiment, I found, that oil of tartar was ponderous enough to flow down, though slowly, into the oil of turpentine at one side of the immersed orifice, whilst the oil passed upwards by it along the other side of the pipe. And my knowledge of this could not but make me a little wonder, that so curious a person, as Monsieur *Pascal*, should somewhere teach, that, if a tube of above fourteen foot long, and having its orifice placed fourteen foot under water, be full of quicksilver, the fluid metal will not all run out at the bottom of the pipe, though the top of it be left open to the air, but will be stopped at a foot high in the pipe. For the impetus, that its fall will give it, must probably make it flow quite out of the pipe: and, not here to mention those trials of ours with quicksilver and slender tubes, that made me think this very improbable, if we consider, that the experiment will not succeed, with much more favourable circumstances, betwixt oil of turpentine and oil of tartar, though the heavier of these two liquors be many times lighter than quicksilver; it tempts me much to suspect, that Monsieur *Pascal* never actually made the experiment, at least with a tube as big as his scheme would make one guess; but yet thought he might safely set it down, it being very consequent to those principles, of whose truth he was fully persuaded. And indeed, were it not for the

the impetus, the quick-silver would acquire in falling from such a height, the rationation were no way unworthy of him.

BUT experiments, that are but speculatively true, should be proposed as such, and may oftentimes fail in practice; because there may intervene divers other things capable of making them miscarry, which are overlooked by the speculator, that is wont to compute only the consequences of that particular thing, which he principally considers; as, in this case, our author seems not to have considered, that in such tubes, as the Torricellian experiment is wont to be made in, the largeness of them would make them unfit for this trial.

AND I have known ingenious men, that are very well exercised in making such experiments, complain, that they could never make this of Monsieur *Pascal's* to succeed. In which attempts, that the size of the tubes much contributed to the unsuccessfulness of the trials, I shall, without repeating what has been already intimated to that purpose, in the following part of this discourse have opportunity to manifest; and, withal, to add as illustrious a proof of this our second paradox, as almost any we have yet given.

P A R A D O X I I I .

That if a body contiguous to the water be altogether, or in part, lower than the highest level of the said water, the lower part of the body will be pressed upward by the water, that touches it beneath.

THIS may be proved by what has been already delivered in the explication of the first experiment: for, where-ever we conceive the lowest part of the body, which is either totally, or in part, immersed in water, to be, there the imaginary superficies being beneath the true superficies, every part of that imaginary superficies must be pressed upwards, by virtue of the weight of the water incumbent on all the other parts of the same superficies; and so that part of it, on which the immersed body chanceth to lean, must, for the same reason, have an endeavour upwards. And if that endeavour be stronger than that, wherewith the weight of the body tends downwards, then (supposing there be no accidental impediment) the body will be buoyed, or lifted up. And though the body be heavier than so much water, and consequently will subside, yet that endeavour upwards of the water, that touches its lower part, is only rendered ineffectual to the raising, or supporting the body, but not destroyed; the force of the heavy body being from time to time resisted, and retarded by the water, as much as it would be, if that body were put into one scale, and the weight of as much water, as is equal to it in bulk, were put into the other.

To confirm this, we may have recourse to what we said in the explication of the second experiment. For in case the slender pipe, wherein the water is kept suspended, be thrust deeper into the oil; or in case there be more oil poured into the vessel, the water will be impelled up higher into the pipe; which it would not be, if the oil, though bulk for bulk a lighter body, did not press against the lower surface of the water, (where alone the two liquors are contiguous) more forcibly than the water, by its gravity, tends downwards. And, even when the liquors rest in an æquilibrium, the oil continually presses upwards against the lower surface of the water; since in that continual endeavour upwards consists its constant resistance to the continual endeavour, that the gravity of the water gives it to descend. And since the same phenomenon happens, whether we suspend water in oil, as in the second experiment, or oil in water, as in the first; it appears, that the proposition is as well applicable

Fig. I. II.

to

to those cases, where the sustained body is specifically heavier, as to those, where it is specifically lighter, than the subjacent fluid.

Fig. IV.

BUT a further and clearer proof of this doctrine will appear in the explication of the next proposition. In the mean time, to confirm that part of our discourse, where we mentioned the resistance made by the water to bodies that sink in it, let us suppose, in the annexed figure, that the pipe E F contains an oil specifically heavier than water, (as are the oils of guaiacum, of cinnamon, or cloves, and some others) and then, that the oil in the pipe, and the water without, being at rest in an æquilibrium, the pipe be slowly raised towards the top of the vessel: it is evident, from our former doctrine, and from experience too, that there will run out drops of oil, which will fall from the bottom of the pipe to that of the vessel; but far more slowly, than if they fell out of the same pipe in the air.

Now, to compute, how much the pressure of the water against the lower parts of the drop amounts to, let us suppose the drop to be G, to whose lowermost part there is contiguous, in any assignable place, where it falls, the imaginary superficies H J. It is evident, that, if the drop of oil were not there, its place would be supplied by an equal bulk of water; which being of the same specific gravity with the rest of the water in the vessel, the surface H J would be laden every where alike; and consequently no part of it would be displaced. But now, the drop of oil being heavier than so much water, that part of the imaginary superficies, on which that drop leans, has more weight upon it, than any other equal part of the same superficies; and consequently will give place to the descending drop. And since the case of every other supposed surface, at which the drop can be conceived to arrive in its descent, will be the same with that of the superficies H J; it will, for the reason newly given, continue falling, till it comes to the bottom of the vessel, which will suffer it to fall no further. And in case the drop G were not, as we suppose it, of a substance heavier *in specie* than water, but just equal to it, the contiguous part of the superficies H J would be neither more nor less charged, than the other parts of the same superficies; and the part leaned on would be neither depressed nor raised, but the drop G would continue in the same place. And so we may prove, (what is affirmed by *Archimedes*, and other hydrostatical writers) that a body, equiponderant *in specie* to water, will rest in any assignable place of the water, where it is put.

AND (to proceed further) since, if the drop G were of a matter but equiponderant to water, it would not sink lower at all, no more than emerge; it follows, that though, being heavier *in specie* than water, yet the gravity, upon whose account it falls, is no more than that, by which it surmounts an equal bulk of water; (since, if it were not for that overplus, the resistance of the water would hinder it from falling at all) and consequently, it loses in the water just as much of the weight it would have in the air, as so much water, weighed likewise in the same air, would amount to.

WHICH is a physical account of that grand theorem of the Hydrostaticks, which I do not remember that I have seen made out in any printed book, both solidly and clearly; the learned *Stevinus* himself, to whom the later writers are wont to refer, having but an obscure, and not physical, demonstration of it.

AND, because this theorem is not only very noble, but, as we elsewhere manifest, very useful, it will not be amiss to add, that it may easily be confirmed by experiment.

FOR, if you take (for instance) a piece of lead, and hang it by a horse-hair (that being supposed very near equiponderant to water) from one of the scales of an exact balance;

balance; and, when you have put a just counterpoise in the other scale, suffer the lead to sink in a vessel of water, till it be perfectly covered with it, but hangs freely in it, the counterpoise will very much preponderate. And, part of the counterpoise being taken out, till the balance be again reduced to an æquilibrium, you may easily, by subducting what you have taken out, and comparing it with the whole weight of the lead in the air, find what part of its weight it loses in the water. And then, if you weigh any other piece of the same lead, suppose a lump of twelve ounces, and hang it by a horse-hair at one scale, you may be sure, that, by putting into the other scale a weight less by a twelfth part, (supposing lead to water to be as twelve to one) that is, eleven ounces, though the weights be far from an æquilibrium in the air, they will be reduced to it, when the lead is covered with water.

THE pressure of water against the lower part of the body immersed in it may be confirmed by adding, that we may thence deduce the cause of the emergency of wood, and other bodies lighter than water; which though a familiar effect, I have not found its cause to have been so much as inquired into by many, nor, perhaps, to have been well rendered by any. If we suppose then, that the pipe be almost filled, not with a sinking, but a swimming oil, as oil of turpentine, if, as in the first experiment, the lower orifice be thrust under water (to a far less depth, than that of the oil in the pipe) and the upper be slowly unstopped, the oil will, as we formerly declared, get out in drops at the bottom of the pipe. But to determine, why these drops, being quite covered and surrounded with water, and pressed by it as well downwards as upwards, should rather emerge than descend, I shall not content myself to say, that water *in specie* is heavier than this kind of oil: for, besides that, in some cases, ere long to be mentioned, I have made the water to depress even this kind of oil, and besides that, it is not every piece of wood, lighter *in specie* than water, that will float upon water, how shallow soever it be; the question is, how this prepollent gravity of the water comes to raise up the oil, though there be, perchance, much more water, for it to break its way thorough, above it, than beneath it.

THE reason then of the emersion of lighter bodies in heavier fluids seems to be this, that the endeavour upwards of the water, contiguous to the lower part of the body, is stronger than the endeavour downwards of the same body, and the water incumbent on it. As, in the former scheme, supposing the drop G to be the oil of turpentine, and to touch the two imaginary and parallel plains H J, K L; it is evident, that upon the lower part of the drop N, there is a greater pressure of water, than upon the upper part of the same drop, M: because, that upon all the surface K L, there is but an uniform, pressure of water A K B L, and upon all the parts of the surface H I, there is a greater weight of water A H B I, except at the part N; for there the oil G, being not so heavy as so much water, the oil being exposed to a greater pressure from beneath, than its own gravity (and that of the water incumbent on it) will enable it to resist, must necessarily give way, and be impelled upward. And the case being the same between that and any other parallel plain, wheresoever we suppose it to be in its ascent, it must consequently be impelled further and further upwards, till it arrive at the top; and there it will float upon the water. Or, (to explicate the matter without figures) when a specifically lighter body is immersed under water, it is pressed against by two pillars of water; the one bearing against the upper, and the other against the lower part: and because the lengths of both these pillars must be computed from the top of the water, the lower part of the immersed body must be pressed upon by a pillar longer than the upper part by the thickness of the immersed body; and consequently must be pressed more upwards than down-

wards.

wards. And by how much the greater disparity of specifick gravity there is betwixt the water and the emerging body, by so much the swifter (*ceteris paribus*) it will ascend: because so much the more will there be of pressure upon all the other imaginary surface, than upon that part, that happens to be contiguous to the bottom of the ascending body.

AND upon the same grounds we may give (what we have not yet met with) a good solution of that problem, proposed by hydrostatical writers, Why, if a cylindrical stick be cut in two parts, the one as long again as the other, and both of them, having been detained under water at the same depth, be let go at the same time, and permitted to emerge, the greater will rise faster than the lesser. For suppose one of these bodies, as *O P*, to be two foot high, and the other, *Q R*, to be half so much, and that the lowermost surfaces of both be in the same imaginary plain, parallel to the uppermost surface of the water, and three foot distant from it; in this case there will be against the lower part of each of the wooden bodies a pressure, (from the laterally superiour water) equal to that upon all the other parts of the imaginary plain, whereto those bodies are contiguous. But whereas upon the upper surface of the shorter body, *Q R*, there will lean a pillar of water two foot high, the pillar of the same liquor, that will lean upon the top of the taller body, *P O*, will be but one foot high; as the attentive considerer will easily perceive. So that the wooden bodies being lighter *in specie* than water, both of them will be impelled upwards: but that compounded pillar (if I may so call it) which consists of one foot of wood, and two foot of water, will, by its gravity, more resist the being raised, than that which consists of two foot of wood, and but one foot of water: so that the cause of the unequal celerity in the ascension of these bodies consists chiefly, (for I would neither overvalue nor exclude concomitant causes) that the difference of the pressure against the upper and lower part of each body respectively is greater in one than in the other.

AND hence we may probably deduce a reason of what we often observe in the distillation of the oils of aniseeds, cloves, and divers aromattick vegetables, in lembecks, by the intervention of water: for oftentimes when the fire has not been well regulated, there will come over, besides the floating oil, a whitish water, which will not in a long time become clear. And as we have elsewhere taught that whiteness to proceed from the numerous reflections from the oily substance of the concrete, by the heat of the fire broken into innumerable little globules, and dispersed through the body of the water; so the reason, why this whiteness continues so long, seems to be chiefly (for I mention not such things, as, the great surfaces, that these little globules have in respect of their bulk) that, because of the exceeding minuteness of these drops, the height of the water, that presses upon the upper part, is almost equal to that of the water, that presses against the lower part. So that the difference between these two pressures being inconsiderable, it has power to raise the drops but very slowly, (inasmuch, that upon this ground I devised a menstruum, wherewith I could mingle oil in drops so exceedingly minute, that even when there were but a few spoonfuls of the mixture, it would continue whitish for divers whole days together) though at length they will emerge; and the sooner, because, whilst they swim up and down, as they frequently chance to meet and run into one another, they compose greater drops; which are (for the reason already given) less slowly impelled up by the water; at the top of which, the chymist, after a due time, is wont to find new oil floating. But whether this be any way applicable to the swimming of the insensible particles of corroded metals in aqua fortis, and other saline menstrua, I must not now stay to inquire.

ONE thing more there is, that I would point at, before I dismiss this paradox; namely, that, for the same reason we have all this while deduced, when the emergent drop, or any other body, floats upon the top of the water, it will sink just so far, (and no farther) till the immerfed part of the floating body be equal in bulk to as much water as is equal in weight to the whole body. For suppose, in the annexed figure, Y to be a cube of wood three foot high, and six pound in weight; this wood, being much heavier than air, will sink into the water, till it come to an imaginary superficies, X W, where, having the position newly described, it will necessarily acquiesce. For all the other equal parts of the superficies, X, W, Q, being leaned upon by pillars of water equal in height to the part X A, or W B, if the whole weight of the wooden cube be greater than that of as much water, as is equal to the immerfed part, it must necessarily sink lower, because the subjacent part of the surface (at V) will be more charged than any of the rest. And, on the other side, if the cube were lighter than as much water as that, whose place the immerfed part takes up; it must, by the greater pressure of the water upon the other parts of the imaginary superficies, X W, than upon that contiguous to the wood, (as at V) be impelled upward, till the pressure of the whole wood upon the part it leans on, be of the same degree with that of the rest of the water, upon the rest of the superficies; and consequently be the same with the water, whose place the immerfed part of it takes up; the lightness of that immerfed part, in respect of so much water, being recompensed by the weight of the unimmerfed part, which is extant above the superficies of the water. And we see, that when a piece of wood falls into water, though, by the impetus it acquires in falling, it passes through divers imaginary plains, that lie beneath its due station; yet the greater pressure, to which each of those plains is exposed in all its other parts, than in that, which is contiguous to the bottom of the wood, does quickly impel it up again, till, after some emersions and subsidings, it rests at length in such a position, as the newly explicated hydrostatical theorem assigns it.

Fig. V.

SCHOLIUM.

THIS ingenious proposition (about floating bodies) is taught and proved, after the manner of mathematicians, by the most subtle *Archimedes*, and his commentators; and we have newly been endeavouring to manifest the physical reason, why it must be true. But partly because the proposition ought to hold, not only in such intire and homogeneous bodies as men exemplify it in, (such as a piece of wood, or a lump of wax) but in all bodies, though of a concave figure, and made up of many bodies of never so differing natures; (and perhaps some of them joined together only by their superincumbency upon one another) and partly, because that a truth, which is one of the main and usefulest of the Hydrostaticks, and may be of so much importance to navigation, has not yet (that I know of) been attempted to be demonstrated, otherwise than upon paper; it will not be amiss, for the satisfaction of such of those, whom it may concern, as are not versed in mathematical demonstrations, to add an experiment, which I made to prove it mechanically, as exactly as is necessary for the satisfaction of such persons.

AFTER, then, having employed several vessels, some of wood, some of latten, and some of other materials, to compass what I desired; we found glasses to be the most commodious we could procure. And therefore, filling a large and deep glass to a convenient height with fair water, we placed in it another deeper glass, shaped like a goblet or tumbler, that it might be the fitter for swimming; and having furnished it first with ballast, and then, for merriment sake, with a wooden deck, by which a tall

maft, with a fail faftned to it, was kept upright; we fraughted with wood, and by degrees poured fand into it, till we had made it fink juft to the tops of certain conspicuous marks, that we had faftned on the outside of the glafs, to oppofite parts thereof. Then obferving, how high the water reached in the larger glafs, (which, by reafon of the vefſel's transparency, was to be feen) we carefully placed two or three marks in the ſame level with the horizontal ſurface of the water; and taking out the floating veſſel as it was, with all that belonged to it, and wiping the outside dry, we put it into a good pair of ſcales, and having found what it amounted to, we weighed in a competently large phial (firſt counterpoifed apart) ſo much water, (to a grain, or thereabouts) and pouring this water into the large glafs above mentioned, we found it to reach to the marks, that we had faftned to the outside of the glafs, and confequently to reach to the ſame height, to which the weight of the floating glafs, and all that was added to make it reſemble a ſhip, had made it ariſe to. By which experiment (which we tried, as to the eſſential parts of it, with veſſels of differing ſizes, ſhapes, and ladings too, as wood, ſtone, quickſilver, &c.) it appears, that the floating veſſel itſelf, with all that was in it, or ſupported by it, was equal in weight to as much water as was equal in bulk to that part of the veſſel, which was under water, ſuppoſed to be cut off from the extant part of the ſame veſſel, by a plain continuing the horizontal ſurface of the water: ſince the weight of the floating veſſel, which raiſed up the water in the larger veſſel to the greateſt height it attained, was the ſame with the weight of the water, which being poured into the larger veſſel (when the other was taken out) raiſed the water therein to the ſame height. We may alſo obtain the ſame end, by a ſomewhat differing way, (which is the beſt way, in caſe the veſſels be too great) *viz.* to obſerve, firſt, by pouring in water out of a bowl or pail, or other veſſel of known capacity, as often as is neceſſary to fill the great veſſel, or ciſtern, or pond, to the top, (or to any determinate height required) and, next, letting out, or otherwiſe removing all that water, to put in its place the veſſel, whoſe weight is to be found out. Thirdly, to let, or pour in water, till the veſſel be afloat, and by its weight raiſe the external water to the height it had before. And laſtly, to examine, how much this water, that was laſt poured in, falls ſhort in weight of the water, that was in it at firſt, and afterwards removed. For this difference will give us the weight of as much water, as is equiponderate to the whole floating veſſel, whether ſmall or great, with all that it either carries or ſuſtains. The hydroſtatical theorem we have been conſidering, and the experiments, whereby we have endeavoured to confirm or illuſtrate it, may (*mutatis mutandis*) be applied to a ſhip with all her ballaſt, lading, guns, and company; it holding generally true, *That* (to expreſs the ſenſe of the propoſition more briefly) *the weight of a floating body is equal to as much water, as its immerſed part takes up the room of.* Whence we might draw ſome arguments in favour of the learned *Stevinus*, (for whoſe ſake it partly was, that I annexed this ſcholium) who, if I miſremember not, does ſomewhere deduce as a corollary from certain hydroſtatical propoſitions, that a whole ſhip, and all that belongs to it, and leans upon it, preſſes no more nor leſs upon the bottom it ſwims over, than as much water, as is equal in bulk to that part of the ſhip, which is beneath the ſurface of the water.

See paradox
the fixth.

PARADOX IV.

That in the ascension of water in pumps, &c. there needs nothing to raise the water, but a competent weight of an external fluid.

THIS proposition may be easily enough deduced from the already mentioned experiments. But yet, for further illustration and proof, we will add that, which follows.

TAKE a slender glass-pipe, (such as was used about the first experiment) and suck into it about the height of an inch of deeply tinted water; and, nimbly stopping the upper orifice, immerse the lower part of the pipe into a glass half filled with such tinted water, till the surface of the liquor in the pipe be an inch (or as low as you would have it) beneath that of the external water. Then pouring on oil of turpentine, till it swim three or four inches, or as high as you please above the water; loosen gently your finger from the upper orifice of the pipe, to give the inclosed air a little intercourse with the external; and you shall see the tinted water in the pipe to be impelled up, not only higher than the surface of the external water, but almost as high as that of the external oil, through which (it being transparent and colourless) the red liquor may be easily discerned.

Now in this case it cannot be pretended, that the ascent of the water in the pipe proceeds from nature's abhorrency of a vacuum; since the pipe being full of air, and its orifice unstopped, though the water should not ascend, no danger of a vacuum would ensue; the air and the water remaining contiguous as before.

THE true reason, then, of the ascent of the water, in our case, is but this; that upon all the other parts of the imaginary superficies, that passes by the immersed orifice of the pipe, there is a pressure partly of water, and partly of the oil swimming upon that water, amounting to the pressure of four or five inches of water; whereas upon that part of the same superficies, whereon the liquor contained in the pipe leans, there is but the pressure of one inch of water: so that the parts near the immersed orifice must necessarily be thrust out of place by the other parts of water, that are more pressed; till so much liquor be impelled up into the pipe, as makes the pressure on that part of the imaginary superficies as great, as that of the oil and water on any other equal part of it. And then, by virtue of the æquilibrium, (often mentioned) the water will rise no further; and, by virtue of the same æquilibrium, it will rest a little beneath the surface of the external oil, because this last named liquor is less heavy, bulk for bulk, than water.

AND by this we may be assisted to give a reason of the ascension of water in ordinary sucking pumps. For as the oil of turpentine, though a lighter liquor than water, and not minglable with it, does, by leaning upon the surface of the external water, press up the water within the pipe, to a far greater height than that of the external water itself; so the air, which, though a far lighter liquor than oil of turpentine, reaches I know not how many miles high, leaning upon the surface of the water in a well, would press it up into the cylindrical cavity of the pump, much higher than the external water itself reaches in the well, if it were not hindered.

Now that, which hinders it in the pump, is either the sucker, which fences the water in the pump from the pressure of the external air, or that pressure itself. And therefore, all that the drawing up of the sucker needs to do, is, to free the water in the pipe from the impediment to its ascent, which was given it by the sucker's leaning
on

on it, or the pillar of the atmosphere's being incumbent on it; as in our experiment, the sides of the pipe do sufficiently protect the water in the pipe from any pressure of the external oil, that may oppose its ascent.

AND lastly, as the water in our pipe was impelled up so high, and no higher, that the cylinder of water in the pipe was just able to balance the pressure of the water and oil without the pipe; so in pumps, the water does rise about thirty three or thirty four foot: and though you pump never so long, it will be raised no higher; because at that height the pressure of the water in the pump, upon that part of the imaginary superficies, that passes by the lower orifice of it, is the same with the pressure, which other parts of that imaginary superficies sustain from as much of the external water, and of the atmosphere, as come to lean upon it.

THAT there may be cases, wherein water may be raised by suction, not upon the account of the weight of the air, but of its spring, I have elsewhere shown; and having likewise in other places endeavoured to explicate more particularly the ascension of water in pumps; what has been said already may suffice to be said in this place, where it is sufficient for me to have shewn, that, whether or no the ascension of water *may have* other causes, yet, in the cases proposed, it *needs* no more than the competent weight of an external fluid, as is the air; whose not being devoid of gravity, the cogency of our experiments has brought even our adversaries to grant us.

FOR confirmation of this, I will here add, because it now comes into my mind, (what might, perhaps, be elsewhere somewhat more properly mentioned) an experiment, that I did but lightly glance at in the explication of the first, and the scholium of the second paradox.

IN order to this, I must advertise, that, whereas I there took notice, that some ingenious men had complained, that, contrary to the experiment proposed by Monsieur *Pascal*, they were not at all able to keep mercury suspended in tubes, however very slender, though the lower end were deeply immersed in water, if both their ends were open; the reasons of my doubting, whether our ingenious author had ever made, or seen the experiment, were not only, that it had been unsuccessfully tried, and seemed to me unlikely to succeed in tubes more slender, than his appeared; but, because the impetus, which falling quicksilver gains by the acceleration of motion it acquires in its descent, must, in all probability, be great enough to make it all run out at the bottom of a tube open at both ends, and filled with so ponderous a liquor, though the tube were very much shorter, than that proposed by Monsieur *Pascal*.

THIS advertisement I premise, to intimate, that, notwithstanding the hopelessness of the experiment, as it had been proposed and tried, I might have reason not to think it impossible to perform, by another way, the main thing desired; which was, to keep quicksilver suspended in a tube, open at both ends, by the resistance of the subjacent water. For, by the expedient I am going to propose, I have been able to do it, even with a liquor much lighter than water.

FINDING then, that even a very short cylinder of so ponderous a fluid as mercury, would, if it were once in falling, descend with an impetus not easy to be resisted by the subjacent liquor, I thought upon the following expedient to prevent this inconvenience. I took a slender pipe, the diameter of whose cavity was little above the sixth part of an inch; and having sucked in, at the lower end of it, somewhat less than half an inch of quicksilver, and nimbly stopped the upper orifice with my finger, I thrust the quicksilver into a deep glass of oil of turpentine, with a care not to unstop the upper orifice, till the small cylinder of quicksilver was eighteen or twenty times

its

its depth beneath the surface of the oil. For by this means, when I unstopped the pipe, the quicksilver needed not (as otherwise it would) begin to fall, as having a longer cylinder, than was requisite to make an æquilibrium with the other fluid. For, by our expedient, the pressure of the oil was already full as great, if not greater, against the lower part of the mercurial cylinder, as that, which the weight of so short a cylinder could exercise upon the contiguous and subjacent oil. And accordingly, upon the removal of my finger, the quicksilver did not run out, but remain suspended in the lower part of the pipe. And as, if I raised it towards the superficies of the oil, the mercury would drop out for want of its wonted counterpoise; so, if I thrust the pipe deeper into the oil, the increased pressure of the oil would proportionably impel up the mercury towards the higher parts of the pipe; which being again a little, and but a little, raised, the quicksilver would fall down a little nearer the bottom of the pipe: and so, with a not unpleasant spectacle, the ponderous body of quicksilver was made sometimes to rise, and sometimes to fall; but still to float upon the surface of a liquor lighter than common spirit of wine itself.

BUT, besides that the experiment, if the maker of it be not very careful, may easily enough miscarry, the divertisement it gives seldom proves lasting; the oil of turpentine, after a while, insinuating itself betwixt the sides of the pipe and those of so short a cylinder of mercury, and thereby disordering all. And therefore, though I here mention this experiment, as I tried it in oil of turpentine, because that is the liquor I make use of all along these paradoxes; and because also I would shew, that a lighter fluid than water (and therefore why not air, if its height be greatly enough increased?) may, by its weight and pressure, either keep the mercury suspended in pipes, or even raise it in them: yet I found water, wherewith I filled tall glasses, a fitter liquor than oil for the experiment, in which though I sought, and found some other phenomena; yet, because they more properly belong to another place, I shall leave them unmentioned in this.

AND since experience shews us, that a cylinder of mercury, of about thirty inches high, is equiponderant to a cylinder of water of about thirty-three, or thirty-four foot high; it is very easy to conclude, that the weight of the external air, which is able to raise and keep suspended thirty-three or thirty-four foot of water in a pump, may do the like to twenty-nine or thirty inches of quicksilver in the Torricellian experiment.

P A R A D O X V.

That the pressure of an external fluid is able to keep an heterogeneous liquor suspended at the same height in several pipes, though those pipes be of very different diameters.

THE contrary of this proposition is so confidently asserted and believed by those mathematicians and others, that favour the doctrine of the schools, that this persuasion of theirs seems to be the chief thing, that has hindered men from acknowledging, that the quicksilver, in the Torricellian experiment, may be kept suspended by the counterpoise of the external air. And a famous writer, that has lately treated, as well of the Hydrostatics, as of the phenomena of the Torricellian experiment, does rely so much upon the falshood of our paradox, that, laying aside all other arguments, he contents himself to confute his adversaries with one demonstration (as he calls it) grounded on the quite contrary of what we here assert. For his objection runs to this sense; That, if it were the pressure of the external air, that kept the quicksilver suspended in the newly-mentioned experiment, the height would

not (as experience shews it is) be the same in all cylindrical pipes, though of very differing bores. For, supposing the height of the mercurial cylinder, in a tube of half an inch diameter, to be twenty-nine inches; it is plain, that a mercurial cylinder of the same height, and three inches in diameter, must weigh divers times as much as the former: and therefore the pressure of the external air being but one and the same, if it be a just counterpoise to the greater cylinder, it cannot be so to the less: and if it be able to keep the one suspended at twenty-nine inches, it must be able to keep the other suspended at a far greater height; which yet is contrary to experience. And indeed this objection is so specious, that, though I elsewhere have already answered it, both by reason and experience, as far forth as its concerns the Torricellian experiment; yet, to shew the mistake, on which it is grounded, it may be very well worth while to make out our proposed paradox, (as that, whose truth will sufficiently disprove that error) by shewing, both *that* the assertion is true, and *why* it must be so.

Fig. VI.

PROVIDE, then, a more than ordinarily wide-mouthed glass, clear, and of a convenient depth; into which having put a convenient quantity of water, deeply tinged with brazil, or some other pigment, fit to the orifice a broad but thin cork, in which, by burning or cutting, make divers round holes of very differing widenesses; into each of which you may thrust a glass cylinder, open at both ends, and of a size fit for the hole, that is to receive it, that so the several pipes may be embraced by these several holes; and, as near as you can, make them parallel to one another, and perpendicular to the superficies of the water, into which they are to be immersed. But we must not forget, that, besides these holes, there is an aperture to be made in the same cork (it matters not much of what figure, or whereabouts) to receive the slender end of a glass funnel; by which oil may be conveyed into the vessel, when it is stopped with the cork. And in the slender part of this funnel we use to put some cotton-wick, to break the violence of the oil, that is to be poured in, which might else disorder the experiment. All this being thus provided, and the cork (furnished with its pipes) being fitted to the orifice of the vessel; if at the funnel you pour in oil of turpentine, and place the glass betwixt your eye and the light, you may, through that transparent liquor, perceive the tinged water to be impelled up into all the pipes, and to rise uniformly in them. And, when this tinged liquor has attained to the height of two or three, or more inches, above the lowermost surface of the external oil, if you remove the funnel, (which yet you need not do, unless there be yet oil in it) you may plainly perceive the water to reach as high in one of the smaller pipes, as in another three or four times as great; and yet the water in the several pipes, as it is evident, is sustained at that height above the level of the other water, by the pressure or counterpoise of the external oil; which therefore, being lighter *in specie* than water, will have its surface somewhat higher without the pipes, than that of the tinged water within them. And if by the aperture, that receives the funnel, you immerse, almost to the bottom of the oil, the shorter leg of a slender glass siphon, at whose longer leg you procure by suction the oil to run out; you shall perceive, that, according as the depth and pressure of the external fluid decreases, so the water in the pipe will subside; and that uniformly, as well in the lesser, as in the greater pipes.

THE reason of this is not difficult to be rendered by the doctrine already delivered. For, suppose E F to be the surface of the water, both within and without the pipes, before any oil was poured on it: if we then suppose the oil to be poured in through the funnel, its lightness in respect of water, wherewith it will not mingle, will keep it from getting into the cavity of the pipes L, M, N; and therefore, spreading itself

on

on the outside of them above, it must necessarily, by its gravity, press down the superficies of the external water, and impel up that liquor into the cavities of the pipes. And if we suppose the pouring on of the oil to be continued, till the uppermost surface of the oil be raised to G H, and that of the external water depressed to I K, (or thereabouts) an imaginary plane passing along the lower orifices of the pipes; I say, the tinted waters in the pipes ought to have their uppermost surfaces in the same level, notwithstanding the great inequality of their bores. For that part of the surface I K, which is comprehended within the circular orifice of the greatest pipe L, is no more charged by the incumbent water, than any other part, equal to that circle of the same imaginary superficies, is by the water or oil incumbent on it; (and consequently, no more than the part, comprehended within the circle of the small pipe N, is by the water contained in that small pipe) the external oil having as much a greater height upon the superficies I K, than the water within the pipe, as is requisite to make the two liquors counterbalance each other, notwithstanding the difference of their specifick gravities. And though the pipe L were twice as big, it would charge the subjacent plane I K no more, than the pressure of the oil on the other parts of the same imaginary surface is able to resist. And yet this pressure of the external oil ought not to be able to raise the water in the slender pipe N higher, than the surface Q in the same level with the surface O. For, if the water were higher in the small pipe, being a heavier liquor than oil, it must press upon that part of the surface I K, it leans on, with greater force, than the external oil upon the other parts of the same plane I K; and therefore with greater force, than the weight of the external oil could resist. And, consequently, the water in the slender pipe must subside, till its surface be inferiour to that of the external oil; since, till then, the difference of their specifick gravities cannot permit them to rest in an æquilibrium. To be short; it is all one to the resistance of the external oil, how wide the cylinder is, that it supports in the pipe; provided the height of it be not greater, in respect of the height of the oil, than the difference of the respective gravities of those two liquors requires. For, so long the pressure of the cylinder of water will be no greater on that part of the imaginary superficies, which it leans upon, than the pressure of the external oil will be on all the other parts of the same superficies; and consequently, neither the one, nor the other of those liquors will subside, but they will both rest in an æquilibrium.

BUT here it will not be amiss to note, first, that it is not necessary, that the glass cylinder L, M, N, should be all of the same length; since the lower orifice being open, the water will rise to the same height within them, whether the parts immersed under the water be exactly of the same length, or no.

AND secondly, That throughout all this discourse, and particularly in the explication of this paradox, we suppose, either that the slenderest pipes, that are employed about these experiments, are of a moderate size, and not exceeding small; or that, in case they be very small, allowance be made in such pipes for this property, that water will rise in them to a greater height, than can be attributed to the bare counterpoise of either the water, or the oil, that impels it upwards, and keeps it suspended. But this difference is of so little moment in our present inquiries, that we may safely neglect it, (as hereafter we mean to do) now we have taken this notice of it for prevention of mistakes.

PARADOX VI.

If a body be placed under water, with its uppermost surface parallel to the horizon; how much water soever there may be on this, or that side above the body, the direct pressure, sustained by the body, (for we now consider not the lateral, nor the recoiling pressure, to which the body may be exposed, if quite environed with water) is no more, than that of a column of water, having the horizontal superficies of the body for its basis, and the perpendicular depth of the water for its height.

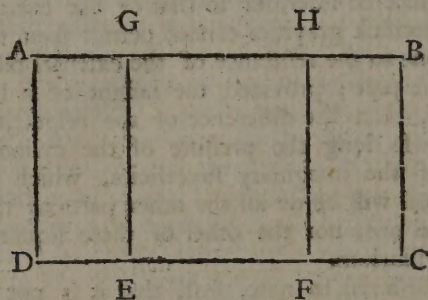
And so likewise,

If the water, that leans upon the body, be contained in pipes open at both ends, the pressure of the water is to be estimated by the weight of a pillar of water, whose basis is equal to the lower orifice of the pipe, (which we suppose to be parallel to the horizon) and its height equal to a perpendicular reaching thence to the top of the water; though the pipe be much inclined towards the horizon, or though it be irregularly shaped, and much broader in some parts, than the said orifice.

STEVINUS, in the tenth proposition of his Hydrostatical Elements, having proposed in more general terms the former part of our paradox, annexes to it a demonstration to this purpose:

HAVING first supposed A B C D to be a solid rectangular figure of water, whose basis E F is parallel to the horizon, and whose height G E is a perpendicular let fall from the uppermost surface of the water to the lowermost; his demonstration is this:

Fig. VII.



If the bottom E F be charged with a greater weight, than that of the water G H F E, that surpluse must come from the adjoining water: therefore, if it be possible, let it be from the water A G E D, and H B C F; which granted, the bottom D E will likewise have a greater weight incumbent on it, upon the score of the neighbouring water G H F E, than that of the water A G E D. And, the reason being the same in all the three cases, the basis F C must sustain a greater weight, than that of the water H B C F: and therefore the whole bottom D C will have a greater weight incumbent on it, than that of the whole water A B C D; which yet (A B C D being a rectangular body) would be absurd. And by the same way of reasoning you may evince, that the bottom E F sustains no less a weight, than that of the water G H F E. And so, since it sustains neither a greater weight, nor a less, it must sustain just as much weight, as the column of water G H F E.

THIS demonstration of the learned Stevinus may well enough be admitted by a naturalist, (though, according to some hypotheses touching the cause and nature of gravity,

gravity, it may fail of mathematical exactness) and by it may be confirmed the first part of our proposed paradox. And some things, annexed by *Stevinus* to this demonstration, may be also applied to countenance the second. But, because this is one of the noblest and usefulest subjects of the *Hydrostaticks*, we think it worth while to illustrate, after our manner, each of the two parts of our paradox by a sensible experiment.

FIRST then, take a slender glass pipe, of an even bore, turned up at one end like the annexed siphon. Into this siphon suck oil of turpentine, till the liquor have filled the shorter leg, and be raised two or three inches in the longer. Then, nimbly stopping the upper orifice with your finger, thrust the lower part of the siphon so far into a deep glass full of water, that the surface of the oil in the longer leg of the pipe may be but a little higher than that of the external water; and, upon the removal of your finger, you will find the surface of the oil to vary but little, or not at all, its former station. And as, if you then thrust the pipe a little deeper, you will see the oil in the shorter leg to begin to be depressed; so, if afterwards you gently raise the pipe toward the top of the water, you shall see the oil not only regain its former station, but flow out by degrees in drops, that will emerge to the top of the water. Now, since the water was able, at first, to keep the oil in the longer leg of the pipe suspended no higher, than it would have been kept by a cylinder of water equal to the orifice of the shorter leg of the pipe, and reaching directly thence to the top of the water; (as may be easily tried, by making a siphon, where the shorter leg may be long enough to contain such a cylinder of water to counterpoise the oil in the longer) and since, when once, by the raising of the pipe, the height of the incumbent water was lessened, the oil did more than counterbalance it, (as appears by its flowing out of the siphon) we may well conclude, that, though there were in the vessel a great deal of water, higher than the immersed orifice of the siphon, (and it would be all one, though the siphon were placed at the same depth in a pond or lake) yet, of all that water, no more did gravitate upon the orifice, than that, which was placed directly over it; which was such a pillar of water, as the paradox describes. Fig. VIII.

AND, by the way, we may hence learn, that though water be not included in pipes, yet it may press as regularly upon a subjacent body, as if it were. And therefore we may well enough conceive a pillar of water, in the free water itself, where there is nothing on any side, but the contiguous water, to bound the imaginary pillar.

BUT I had forgot to add, that the first part of our paradox will hold, not only when the water, superior to the body it presses upon, is free; but also, when it is included in vessels of never so (seemingly) disadvantageous a shape. For, if you so frame the shorter leg of a siphon, that it may expand itself into a funnel, like that of *fig. 6.* employed about the proof of the foregoing (fifth) paradox; (for which purpose the legs must be at a pretty distance from each other:) though you fill that funnel with water, the oil in the longer and slender leg of the siphon will be able to resist the pressure of all the water, notwithstanding the breadth of the upper part of the funnel. So that, even in this case also, the surface of the oil in the longer leg will be but a little higher than that of the water in the funnel.

FOR further confirmation of this, we caused to be made a siphon, so shaped, that one of the legs (which were parallel, and of the same bore) had in the midst of it a sphere of glass, save that it communicated with the upper and lower parts of the same leg.

IN the uniform leg of the siphon, we put a convenient quantity of oil of turpentine, and into the other as much water, as filled not only the lower part of it,

but the globular part too. And yet we did not find, that all this water was able to keep up the oil in the uniform leg, at a greater height, than if the leg, that contained the water, had been uniform too; as much of the water in the globe, as was not directly over the lower orifice of it, being supported by the lateral parts (if I may so call them) of the same globe. And if that leg were, instead of water, filled with oil, and the uniform leg with water; notwithstanding the far greater quantity of oil, that was necessary to fill that leg, whereof the hollow sphere was but a part; the water in the uniform leg would not be kept up, so much as to the same height with the oil in the misshapen leg.

Fig. IX.

BUT to make this matter yet the more clear, we caused a siphon to be made of the figure expressed in the adjoining scheme; into which having poured a convenient quantity of mercury, till it reached in the shorter leg CD, almost to the bottom of the globulous part E, and in the longer leg AB, to an equal height: we afterwards poured a sufficient quantity of water into the said longer leg AB, which drove away the quicksilver, and impelled it up in the shorter leg till it had half, or more than half, filled the cavity of the globular part E; (which yet we did not wholly fill with quicksilver, because the tube AB was not long enough for that purpose:) and then we observed, that, notwithstanding the great weight of (that body, which is of all bodies, save one, the most ponderous) quicksilver, which was contained in the lower part of the same leg of the siphon, the surface of the quicksilver HG, was impelled up as high by the water in the leg AB, as the disparity of the specifick weights of those two liquors (whereof one is about fourteen times as heavy as the other) did require: so that it appeared not, that, for all the great weight of quicksilver, contained in the globulous cavity E, there pressed any more upon the slender and subjacent part EC of that leg, than as much as was placed directly over the lower orifice of the said cavity E. So that the other, and lateral parts of that mercury being supported by the concave sides of the glass, whereunto they were contiguous, the water in the leg AB appeared not any more pressed by the quicksilver, than if the leg CD had been, as well as the other, of an uniform bigness; and, by this means, if we had made the hollow globe of a large diameter, a small quantity of water, poured into the leg AB, might have been able to raise a quantity of quicksilver exceedingly much heavier than itself. But then so little water can raise the quicksilver, in so broad a pipe, but to an inconsiderable height.

Fig. X.

TO make out the second part of our paradox by an experiment, we took three glass-pipes; the one made like a bolt-head, with a round ball, and two opposite stems; the other was an irregular pipe, blown with an elbow, wherewith it made an angle; and the third was as irregularly shaped, as I could get it blown; being in some places much broader, and in some much narrower than the lower orifice of it. And these two last named pipes had their upper ends so inserted into holes, made fit for them in a broad piece of cork; that, when they were immersed, they made not right angles, but very oblique ones, with the horizontal surface of the liquor. The other glass likewise, which consisted of a great bubble, and two opposite pipes, was fastned to the same cork, which having beforehand been made fit for a wide-mouthed glass of a good depth, and half filled with water, was thrust as a stopple into the mouth of the said glass, so that the water ascended a pretty way into each of the three pipes by their lower orifices, which, as well as the upper, we left open; then a good quantity of oil of turpentine being poured into the same vessel through a funnel, the water was by the incumbent oil impelled up to the height of two or three inches in each of the three pipes. Which argues, that, notwithstanding their being so unequal in bigness, and so irregular in shape, (inasmuch that we guessed one of them was ten

or

or twelve times greater in one part, than in another, or than it was even at the orifice) the water, contained in each of them, pressed upon its lower orifice no more (I do not add, nor no less) than it would have done, if it had been a cylinder, having the orifice for its basis, and the perpendicular depth of the water and oil above, for its height. For in case each of the pipes had contained but such a cylinder of water, that water would nevertheless have had its uppermost superficies at the same height: and, on the other side, it would have been impelled up beyond it, if its weight did not as strongly endeavour to depress the immediately subjacent water, as the pressure of the external fluids endeavoured to impel it up.

AND since the height of the water was about the same in the several pipes, though two of them, being very much inclined, contained much more water than if they were erected; yet by the same way of reasoning we may gather, that the imaginary plain, passing by the immersed orifice of either of these inclining pipes, sustained no more of pressure, than it would have done from a shorter cylinder of water, if erected. And indeed, in all these cases, where a pipe either is broader in other places than at its lower orifice, or inclined any way towards the horizon, the weight of the contained liquor is not all supported by the liquor, or the body contiguous to the lower orifice, but partly by the sides of the pipe itself. And therefore if, when in a slender pipe you have brought a parcel of oil of turpentine to be in an æquilibrium with the external water, as in the experiment belonging to the first paradox; if, I say, when this is done, you incline the pipe towards the sides of the glass, you may indeed observe the surface of the oil in the pipe to be, as before, a little higher than that of the water without it: but you shall likewise see, that though the orifice of the pipe were not thrust deeper into the water, yet there will be a pretty deal of water got up into the pipe; because the oil not leaning now upon the water only, as it did before, but partly upon the water, and partly upon the pipe, its pressure upon the subjacent water is considerably lessened; and thereby the external water, whose pressure is not diminished too, is able to impel up the oil, and intrude for a little way into the pipe. But if you re-erect the pipe, the pressure of the oil being then again exerted upon the subjacent water, it will be able to depress, and drive it again out of the cavity of the pipe.

AND to this agrees very well what we further tried as follows: We caused three pipes to be blown (shaped as the adjoining figures;) one having in it divers acute angles; the other being of a winding form, like a skrew or worm of the limbeck; and the third very irregularly crooked; and yet each of these pipes having all its crooked parts, and some of its streight and erected parts, filled with oil of turpentine; being thrust to a convenient depth under water and unstopped there, (after the manner already often declared) we found, that, according to our paradox, the surface of the oil in the pipe was higher than that of the water without it, as much as it would have been in case the pipe had been streight, (as we tried, by placing by the crookedest of them a streight pipe with oil in it) though the quantity of the oil, in one of these pipes, were perhaps three times as much as would have sufficed, if the pipe had been strait: so that this surplussage of oil did not press upon the subjacent water, (for if it had done so, the oil would have run out of the pipe.) And I remember, that lifting up as much of one of these crooked pipes, as I thought fit, somewhat above the surface of the water; when the superficies of the oil in the pipe was not above half an inch higher than that of the water without it, I estimated, that the crooked pillar of oil, contained in that part of the pipe, which was above the surface of the water, was about seven or eight inches long. So true it is, that the pressure of liquors, contained in pipes, must be computed by the perpendicular that measures their height, whatever be their length or bigness.

Fig. XI.

SCHOLIUM.

THE learned *Stevinus*, having demonstrated the proposition we lately mentioned out of him, subjoins divers consecutaries, of which the truth hath been thought more questionable, than that of the theorem itself. And therefore he thought fit to add a kind of appendix to make good a paradox, which seems to amount to this; that if, in the cover of a large cylindrical box, exactly closed, there be perpendicularly erected a cylindrical pipe open at both ends, and reaching to the cavity of the box; this instrument being filled with water, the circular basis of it will sustain a pressure, equal to that of the breadth of the basis and height of the pipe.

I CHOSE thus to express this theorem, (which might be, according to *Stevinus*, proposed in more general terms) because this way of expressing it will best suit with the subsequent experiment, and may consequently facilitate the understanding of the paradox. But though the learned *Stevinus*'s aims were to be commended; who finding this proposition doubted, seems to have had a great mind to give an experimental demonstration of it, and therefore proposes no less than five pragmatistical examples (as he calls them) to make out the truth of what he asserts; yet in this he hath been somewhat unhappy, that that experiment, which alone (for ought I can find) has been tried of all the five, is rejected as incompetent by those, that profess to have purposely made trial of it. And indeed, by reason of the difficulty of bringing them to a practical examen, I have somewhat doubted, whether or no this useful writer did ever make all those trials himself; rather than set down the events, he supposed they must needs have, as presuming his conjectures rightly deduced from a demonstrative truth. Wherefore though another of the experiments, he proposes, be not free from difficulty, yet having, by the help of an expedient, made it practicable, we are induced by its plainness and clearness to prefer it to what else he proposes to the same purpose.

See Fig.
XII.

WE provided then a vessel of latten, of the figure expressed in the scheme, and furnished it with a loose bottom C D, made of a flat piece of wood covered with a soft bladder, and greased on the lower side near the edges, that leaning on the rim of wood G H, contiguous every where to the inside of the latten, it might be easily lifted from off this rim; and yet lie so close upon it, that the water should not be able to get out between them: and to the midst of this loose bottom was fastned a long string, of a good strength, for the use hereafter to be declared. The instrument thus fitted, the water was poured in apace at the top A B, which, by its weight pressing the false bottom C D against the subjacent rim G H, contributed to make the vessel the more tight, and to hinder its own passing. The vessel being filled with water, we took the forementioned string, one of whose ends was fastned to I, the middle part of the loose bottom, and, tying the other end K to the extremity of the beam of a good pair of scales, we put weights one after another into the opposite scale, till at length those weights lifted up the false bottom C D from the rim G H; and consequently lifted up the incumbent water; which presently after ran down between them. And having formerly, before we poured in any water, tried what water would suffice to raise the bottom C D, when there was nothing but its own proper weight, that was to be surmounted; we found, by deducting that weight from the weight in the scale, and comparing the residue with the weight of as much water as the cavity of the broad, but very shallow cylinder, B E C H G D F, would have alone (if there had been no water in the pipe A I) amounted to; we found, I say, by comparing these particulars, that the pressure upon C D was by so very great odds more, than could have been attributed to the weight of so little water, as the instrument,

ment, pipe and all contained, in case the water had been in an uniform cylinder, and consequently a very shallow one, of a basis as large as that of our instrument; that we could not but look upon the success, as that, which, though it did not answer what the reading of *Stevinus* might make a man expect; yet may deserve to be further prosecuted, that whether or no the paradox of *Stevinus* (which not only some others, but the learned Dr. *Wallis* himself question) will hold, the inquiry he has started, may be so pursued, as to occasion some improvement of this part of Hydrostaticks: where, to define things with certainty, will perhaps be found a difficult task than at first glance one would think; both because divers speculative things must be taken into consideration, whose theory has not perhaps yet been cleared, and because of the difficulty, that will be found in practice by them, that shall go about to make *Stevinus's* experiments, or others of that sort, with all requisite accurateness. As indeed, it is far easier to propose experiments, which would in likelihood prove what we intend, in case they could be made, than to propose practicable expedients, how they may be made.

PARADOX VII.

That a body immersed in a fluid sustains a lateral pressure from the fluid; and that increased, as the depth of the immersed body, beneath the surface of the fluid, increaseth.

THOUGH I shall not wonder, if this proposition seems strange enough to most readers; yet I think I could make it out by several ways, and particularly by one, that is plain and easy, being but that which follows:

TAKE then a slender glass-pipe (like that employed about the first experiment) and cause it to be bent within two or three inches of one end, so that the longer and the shorter legs, E F and F G, may make, as near as can be, a right angle at F; then dipping the orifice of the shorter leg F G in oil of turpentine, suck into the siphon (if I may so call it) as much of the liquor as will fill the shorter leg, and reach two or three inches high in the longer: then nimbly stopping the upper orifice with your finger, immerse the lower part of the glass under water, in such manner, as that the longer leg E F may make, as to sense, right angles with (A B) the horizontal surface of the water; and the shorter leg F G may be so far depressed under that surface, that I K, the superficies of the oil in the longer leg, be but a little higher than A B, that of the external water. Then, removing your finger, you may observe, that the oil in the siphon will continue (with little or no change) in its former station. * By which it appears, that there is a lateral pressure of the water against the oil contiguous to G, the orifice of the shorter leg of the pipe; since it is only that pressure, that hinders the efflux of the oil at that orifice, notwithstanding the pressure of the perpendicular cylinder of oil, that would drive it out.

Fig. XIII.

AND that this pressure of the perpendicular cylinder doth really urge the oil in the shorter leg to flow out, you may learn, by slowly lifting the siphon (without changing its former posture) towards the surface of the water. For as the lower leg comes nearer and nearer to that surface, (to which, as I newly intimated, it is still to be kept parallel) the oil in the horizontal leg will be driven out in drops, by the pressure of the other oil in the perpendicular leg.

THAT likewise, before you begin to raise the siphon, the lateral pressure of the water against the lower orifice of it is, at least in such experiments, near about the same with what would be the perpendicular pressure of a cylinder of water, reaching from the same orifice G (or some part of it) to the top of the water,

may

may be gathered from hence, that the surface of the oil in the longer leg will be a little higher than that of the external water, as (by reason of the often mentioned comparative levity of the oil) it would be, if we suppose, that a pipe of glass of the same bore, and reaching to the top of the water, being fitted to the orifice of the horizontal leg (as in the annexed figure the cylinder, G H) were filled with water.

AND, to make out the latter part of our proposition, we need add no more, than that, if you plunge the siphon deeper into the water, you shall find the oil, by the lateral pressure of the water, driven by degrees quite out of the shorter leg into the longer: and if you thrust it yet deeper, you may observe, that the longer leg will admit a cylinder of water, upon which that of oil will swim; the whole oil alone being unable to counterbalance the lateral pressure of the water at so great a depth.

By which last circumstance, it appears, that water has also a lateral pressure against water itself, and that increased according to its depth; since otherwise the external water could not impel that in the horizontal leg of the siphon into the perpendicular leg, though, to do so, it must surmount the weight or resistance of the whole cylinder of oil, that must be here violently raised in the said perpendicular leg.

BUT if you gently raise the siphon again, the lateral pressure of the water against the immersed orifice being diminished, (according as the distance of that orifice G from the horizontal surface, A B, comes to be lessened) the prevalent oil will drive out the water, first out of the longer leg, and then out of the shorter, and will at length flow out in drops at the immersed orifice, and thence emerge to the top of the water.

BESIDES, when the oil in the siphon does just counterbalance the external water, if you keep the shorter leg parallel to the surface of the water, and move the orifice of it this way or that way, and place it nearer or further off from the middle or from the sides of the glass, (provided you keep it always at the same depth under the water) you will find the oil in the longer leg to continue (as to sense) at the same height. Whence we may learn (what I have not yet found mentioned by any writer) that, even in the midst of the water, we may suppose a pillar of water, of a basis equal to the side of an immersed body, (and reaching to the lowest part of it) and that, though this imaginary aqueous pillar, such as in our figure G H, be not included in any solid body, or stable superficies; nevertheless its lower parts will have a lateral pressure tending outwards, against the imaginary sides, from the weight of the water, that is above these subjacent and lateral parts; and will have that pressure increased proportionably to the height to which the imaginary pillar reaches above them. Which observation, being duly noted and applied, may be of no mean use in the explication of divers hydrostatical phenomena.

AND lastly, if, instead of holding E F, the longer leg of our siphon, perpendicular, (and consequently the shorter parallel to the horizon) you variously incline the former, so as to bring it to make an obtuse or an acute angle with the superficies of the water A B; though by this means the shorter and immersed leg, F G, will in situation sometimes respect the bottom, and sometimes the top of the glass; yet in all these oblique situations of this leg, and the immersed orifice of it, G, the oblique pressure of the water will so much depend upon the height of the surface of the liquor above the orifice, and so much conform to the observations already delivered, that you shall still see the surface of the oil I K, in the longer pipe, to be a little, and but a little superiour to that of the external water, A B, and so the æquilibrium betwixt

betwixt the liquor, or liquors, within the siphon, and the water without it, will even in this case also be maintained.

SCHOLIUM.

REMEMBRING on this occasion an experiment, which, though it do not shew what the precise quantity of lateral pressure is, that the lower parts of the fluid may sustain from the more elevated; yet it may confirm the foregoing paradox, and by its phenomena afford some hints, that may render it not unacceptable; I shall subjoin it, as I set it down not long after I devised it.

IN the first place then, there was made a glass bubble with a slender neck; and (in a word) of the figure expressed in the annexed scheme: this bubble I caused to be so poised, that, though it would float upon the water, yet the addition of a weight small enough would suffice to make it sink.

Fig. XIV.

THIS done, I provided a very large wide-mouthed glass, and caused to be fitted to it, as exactly as I could, a stopple of cork, which being strongly thrust in, would not easily be lifted up. In the middle of this cork there was burned, with a heated instrument, a round hole; through which was thrust a long slender pipe of glass; so that the lower end of it was a pretty way beneath the cork, and the upper part of it was, as near as could be, at right angles with the upper part of the said cork. And in another part of the stopple, near the edge, there was made another round hole, into which was likewise thrust another small pipe; whose lower part reached also a pretty way beneath the cork, but its upper part was but about two or three inches high; and the orifice of this upper part was carefully closed with a stopple and cement. Then the glass-vessel being filled with water, and the poised bubble being made to float upon it, the stopple or cover of the great glass-vessel was put on, and made fast with a close cement, that nothing might get in or out of the vessel, but at the long slender pipe: which was fastened into the cork (as was also the shorter pipe) not only by its own fitness to the hole it passed through, but by a sufficient quantity of the same cement, carefully applied to stop all crevices.

THE instrument thus prepared, (and inclined this or that way, till the floating bubble was at a good distance from that end of the long pipe, which reached a pretty way downwards beneath the surface of the water) we began to pour in some of that liquor at the open orifice of the pipe E F; and, the mouth of the vessel being exactly stopped, the water, for want of another place to receive it, ascended into the pipe, through which it had fallen before. And, if I held my hand, when the water I had poured in was able to reach but to a small height in the cylinder, as for instance, to the superficies J; the bubble X would yet continue floating. But, if I continued pouring, till the water in the pipe had attained a considerable height above the surface of that in the vessel, as if it reached to K; then the bubble X would presently sink to the bottom of the vessel, and there continue, as long as the water continued at so great a height in the pipe E F.

THIS experiment will not only teach us, that the upper parts of the water gravitate upon those, that are under them, but (which is the thing we are now to confirm) that in a vessel, that is full, all the lower parts are pressed by the upper, though these lower be not directly beneath the upper, but aside of them, and perhaps at a good distance from the line, in which they directly press; these things, I say, may be made out by our experiment. For the addition of the cylinder of water K J, in the pipe E F, makes the bubble X subside; as the force or pressure of any other heavy body upon the water in the vessel would do. And since (as may be gathered from

the reason formerly given, in the proof of the second paradox, of the sinking of poised bubbles) the included air in our bubble was notably compressed; it will follow, that the cylinder of water K I did press the subjacent water in the vessel: for, without so doing, it could not be able to compress the air in the bubble. And since the said bubble did not swim directly under, or near the pipe E F, but at one side of it, and at a pretty distance from it, nay, and floated above the lower orifice F of the pipe; it is evident, that that aqueous cylinder I K does not only press upon the water, or other bodies, that are directly under it; but upon those also, that are laterally situated in respect of it, provided they be inferior to it.

AND, according to this doctrine, we may conceive, that every assignable part of the sides of the vessel does sustain a pressure, increased by the increase of that part's depth under water, and according to the largeness of the said part. And therefore, if any part were so weak, as that it would be easily beaten out, or broken by a weight equal to the cylinder I K, (making always a due abatement for the obliquity of the pressure) it would not be fit to be a part of our vessel: nay, the cork itself, though it be above the surface of the water in the vessel; yet, because the water in the pipe is higher than it, each of its parts resists a considerable pressure, proportionate to its particular bigness, and to the height of the water in the pipe. And therefore, if the cork be not well stopped in, it may be lifted up by the pressure of the water in the pipe, if that be filled to a good height. And if the cement be not good and close, the water will (not without noise) make itself a passage through it. And if the stopple G, of the shorter pipe G H, (which is placed there likewise to illustrate the present conjecture) do not firmly close the orifice of it, it may be forced out, not without violence and noise. And, for further satisfaction, if, instead of the stopple G, you close the orifice with your finger, you shall find it pressed upwards as strongly, as it would be pressed downwards by the weight of a cylinder of water of the breadth of the pipe, and of a not inconsiderable height, (for it is not easy to determine precisely, what height) so that (to be short) in the fluid body we made our trial with, the pressure of the superiour parts was communicated, not only to those, that were placed directly under them, but even to those, that were but obliquely so, and at a distance from them.

I HAD forgot to confirm, that it was the pressure of the superiour parts of the water, that made our floating bubble sink, by such another circumstance, as I took notice of in some of the former experiments; *viz.* that, when it lay quietly at the bottom of the vessel, if, by inclining the instrument, we poured off as much of the water in the pipe E F, as sufficed competently to diminish its height above the water in the vessel A B C D, the air in the bubble, finding its former pressure alleviated, would presently expand itself, and make the bubble emerge. And to show, that the very oblique pressure, which the bubble sustained from the water in the pipe, was not over-much differing from that, which it would have sustained from an external force, or from the weight of water placed directly over it; I caused two such bubbles to be poised, and having put each of them into a long cylindrical glass, open above, and filled with water, upon which it floated, if we thrust it down a little way, it would (agreeably to what hath been above related) ascend again: so that we were forced to thrust it down to a good depth, before the pressure of the incumbent water was great enough to make it subside.

AND, perhaps, it will not be impertinent to take notice, before we conclude, how the pressure of such differing fluids, as air and water, may be communicated to one another. For having sometimes forbore to fill the vessel A B C D quite full of water, so that, when the cork was fitted to it, there remained in it a pretty quantity

of air, (as between the surface L M, and the cork) nevertheless, if the stopple or cork were very closely put in, the pressure of the water, that was afterwards poured into the pipe E F, from J to K, would make the bubble sink little otherwise, for aught I took notice of, than if the vessel had been perfectly filled with water; the air, (above L M) that was both imprisoned and compressed, communicating the pressure it received to the water contiguous to it.

PARADOX VIII.

That water may be made as well to depress a body lighter than itself, as to buoy it up.

HOW strange soever this may seem to those, that are prepossessed with the vulgar notions about gravity and levity; it need not be marvelled at by those, that have considered, what has been already delivered. For since, in fluid bodies, the upper parts press upon the lower, and upon other bodies, that lie beneath them: and since, when a body is unequally pressed by others, whether lighter, or heavier than itself, it must necessarily be thrust out of that place, where it is more pressed, to that, where it is less pressed; if that a parcel of oil be, by a contrivance, so exposed to the water, as that the water presses against its upper superficies, and not against the undermost, or lateral parts of it; if we suppose, that there is nothing (whose pressure is not inferior to that of the water) to hinder its descent, (supposing, withal, that the oil and water cannot pass by one another; for which cause we make use of a slender pipe) the oil must necessarily give way downwards, and consequently be depressed, and not buoyed up. This is easily exemplified by the following experiment.

TAKE a slender glass siphon E F G H, of the bore we have often mentioned, Fig. XV. whose shorter leg G H may be about three or four inches long, and as parallel, as the artificer can make it, to the longer E F; dip the shorter leg in oil of turpentine, till the oil quite fill the shorter leg, and reach to an equal height in the longer, as from F to J. Then, stopping the orifice E of the longer leg with your finger, and immersing the replenished part of the siphon about an inch under water, you shall perceive, that, as you thrust it lower and lower, upon the removal of your finger, the oil in the shorter leg will be made to sink about an inch, or somewhat more; and as, afterwards, you thrust the pipe deeper, the oil in the shorter leg will, by the weight of the incumbent water H K, be driven downward more and more, till it come to the very bottom of the shorter leg; whence, by continuing the immersion, you may impel it into the longer. The cause of which phenomenon I suppose to be already clearly enough assigned, to make it needless to add any thing here about it.

It remains, that, before I proceed to the next proposition, I add; that, to exemplify at once three paradoxes, (both this, and the next foregoing, and the second) I caused to be made a slender glass-pipe, of the figure expressed in the annexed scheme, and having, by the lower orifice L, sucked into it as much oil of turpentine, as reached, in the longest leg N O, as high as the top of the other part of the glass; (namely, to the part P, in the same level with the orifice L) I first stopped the upper orifice of it, O, with my finger. And then, thrusting it as before under water to a convenient depth, upon the removal of my finger, the external water did first drive away the oil, that was in L M, that part of the crooked pipe which was parallel to the horizon; then it depressed the same oil to the bottom of the shorter leg, that is, from M to N: and lastly, it impelled it all up into the longer leg N P O, to what height I thought fit. So that the oil was pressed by the water, both laterally, down-

wards, and upwards: the causes of which are easily deducible from the doctrine already delivered.

PARADOX IX.

That, whatever is said of positive levity, a parcel of oil lighter than water, may be kept in water without ascending in it.

TO make out what I have to represent about this paradox the more intelligible, the best way perhaps will be to set down the considerations, that induced me to judge the thing it pretends to feasible. And in order to this, it would be expedient to consider, why it is, that a body lighter *in specie* than water, being placed never so much beneath the superficies of that liquor, will rather emerge to the top, than sink to the bottom of it; if we had not already considered that problem in the explication of the third paradox. But being now allowed to apply to our present purpose what hath been there delivered, I shall forthwith subjoin, that it was easy enough for me to collect from hence, that the reason, why it seems not possible, that a parcel of oil lighter than water should without violence be kept from emerging to the top of it, being this, *That since the surface of a vessel full of standing water is (physically speaking) horizontal, the water, that presses against the lower part of the immersed body, must needs be deeper than that, which presses against the upper: If I could so order the matter, that the water, that leans upon the upper part of the body should, by being higher than the level of the rest of the water, have a height great enough to balance that, which presses against the lower, (and the bodies not shift places, by passing one by the other) the oil might be kept suspended betwixt two parcels of water.*

To reduce this to practice, I took the following course; having sucked into a slender pipe (such as that employed about the first experiment) about an inch of water, and kept it suspended there, by stopping the orifice of the pipe; I thrust the lower part of the pipe about two inches beneath the surface of some oil of turpentine (which, to make the effect the clearer, I sometimes tinge deeply with copper) then removing my finger, the oil being pressed against the immersed orifice with a greater force, than the weight of so little suspended water could resist, that oil was impelled into the lower part of the pipe to the height of near an inch; and then again I stopped the upper orifice of the pipe with my finger, and thereby keeping both the liquors suspended in it, I thrust the pipe into a glass full of water, three or four inches beneath the surface of it; and then (for the reason just now given) the water, upon the removal of my finger, will press in at the lower orifice of the pipe, and impel up the oil, till they come to such a station, as that expressed in the annexed scheme: where P Q is the water, newly impelled up into the pipe, Q R is the oil, and R S the water, that was at first sucked into the pipe. For in this station these three liquors do altogether as much gravitate upon the part P, as the incumbent water alone does upon the other parts of the imaginary superficies G H; and yet the oil, R Q, does not ascend, because the diffuence of the water, R S, being hindered by the sides of the pipe, its superficies, T S, is higher than A D, the superficies of the rest of the water; by which means the incumbent water may be brought to have upon the upper part R of the oleous cylinder, as great a pressure as that of the water, that endeavours to impel upwards the lower part Q of the same suspended cylinder of oil.

PARADOX X.

That the cause of the ascension of water in siphons, and of its flowing through them, may be explicated without having a recourse to nature's abhorrency of a vacuum.

BOTH philosophers and mathematicians having too generally confest themselves reduced to fly to a *fuga vacui*, for an account of the cause of the running of water, and other liquors through siphons: and even those moderns, that admit a vacuum, having (as far as I have met with) either left the phenomenon unexplicated, or endeavoured to explain it by disputable notions: I think the curious much obliged to Monsieur *Pascal*, for having ingeniously endeavoured to shew, that this difficult problem need not reduce us to have recourse to a *fuga vacui*. And indeed his explication of the motion of water in siphons, seems to me so consonant to hydrostatical principles, that I think it not necessary to alter any thing in it. But as for the experiment he propounds to justify his ratiocination, I fear his readers will scarce be much invited to attempt it. For, besides that it requires a great quantity of quicksilver, and a new kind of siphon, fifteen or twenty foot long; the vessels of quicksilver must be placed six or seven yards under water, that is, at so great a depth, that I doubt whether men, that are not divers, will be able conveniently to observe the progress of the trial.

WHEREFORE we will substitute a way, which may be tried in a glass tube, not two foot deep, by the help of another peculiarly contrived glass, to be prepared by a skilful hand. Provide then a glass tube *ABCD*, of a good wideness, and half a yard or more in depth; provide also a siphon of two legs, *FK*, and *KG*, whereunto is joined (at the upper part of the siphon) a pipe *EK*, in such manner, as that the cavity of the pipe communicates with the cavities of the siphon: so that if you should pour in water at *E*, it would run out at *F* and *G*. To each of the two legs of this new siphon must be tied with a string a pipe of glass, *I* and *H*, sealed at one end, and open at the other; at which it admits a good part of the leg of the siphon to which it is fastened, and which leg must reach a pretty way beneath the surface of the water, wherewith the said pipe is to be almost filled. But as one of these legs is longer than the other, so the surface of the water in the suspended pipe *I*, that is fastened to the shorter leg *KF*, must be higher (that is, nearer to *K* or *AB*) than the surface of the water in the pipe *H*, suspended from the longer leg *KG*; that (according to what is usual in siphons) the water may run from a higher vessel to a lower.

ALL things being thus provided; and the pipe *EK* being held, or otherwise made fast, that it may not be moved; you must gently pour oil of turpentine into the tube *ABCD*, (which, if you have not much oil, you may beforehand fill with water, till the liquor reach near the bottom of the suspended pipes, as to the superficies *XY*) till it reach higher than the top of the siphon *FKG*, (whose orifice *E* you may, if you please, in the mean time close with your finger, or otherwise, and afterwards unstop) and then the oil pressing upon the water, will make it ascend into the legs of the siphon; and pass through it, out of the uppermost vessel *J*, into the lowermost *H*; and if the vessel *J* were supplied with water, the course of the water through the siphon would continue longer, than here (by reason of the paucity of water) it can do.

Now in this experiment we manifestly see the water made to take its course through the legs of a siphon from a higher vessel into a lower; and yet the top of the siphon being perforated at *K*, the air has free access to each of the legs of it, through the hollow pipe *EK*, which communicates with them both. So that, in our case, (where
there

Fig. XVIII.

there is no danger of a vacuum, though the water should not run through the siphon) the fear of a vacuum cannot with any shew of reason be pretended to be the cause of its running. Wherefore we must seek out some other.

AND it will not be very difficult to find, that it is partly the pressure of the oil, and partly the contrivance and situation of the vessels; if we will but consider the matter somewhat more attentively. For the oil, that reaches much higher than K, and consequently than the legs of the siphon, presses upon the surface of the external water, in each of the suspended pipes I and H. I say the external water, because the oil floating upon the water, and the orifices of both the legs F and G, being immersed under the water, the oil has no access to the cavity of either of those legs. Wherefore, since the oil gravitates upon the water without the legs, and not upon that within them, and since its height above the water is great enough to press up the water into the cavity of the legs of the siphon, and impel it as high as K, the water must by that pressure be made to ascend.

AND this raising of the water happening at first in both legs, (for the cause is in both the same) there will be a kind of conflict about K betwixt the two ascending portions of water; and therefore we will now examine, which must prevail.

AND if we consider, that the pressure, sustained by the two parcels of water in the suspended pipes I and H, depends upon the height of the oil, that presses upon them respectively; it may seem (at the first view) that the water should be driven out of the lower vessel into the higher. For if we suppose that part of the shorter leg, that is unimmersed under water, to be six inches long, and the unimmersed part of the longer leg to be seven inches; because the surface of the water in the vessel I is an inch higher than that of the water in the vessel H, it will follow, that there is a greater pressure upon the water, whereinto the longer leg is dipped, by the weight of an inch of oil: so that that liquor being an inch higher upon the surface of the water in the pipe H, than upon that in the pipe I, it seems, that the water ought rather to be impelled from H towards K, than from I towards K.

BUT then we must consider, that, though the descent of the water in the leg G be more resisted than that in the other leg, by as much pressure as the weight of an inch of oil can amount to; yet being longer by an inch than the water in the leg F, it tends downwards more strongly by the weight of an inch of water, by which length it exceeds the water in the opposite leg. So that an inch of water being (*cæteris paribus*) heavier than an inch of oil; the water in the longer leg, notwithstanding the greater resistance of the external oil, has a stronger endeavour downwards, than has the water in the shorter leg; though the descent of this be resisted but by a depth of oil less by an inch. So that all things computed, the motion must be made towards that way, where the endeavour is most forcible; and consequently the course of the water must be from the upper vessel, and the shorter leg into the longer leg, and so into the lower vessel.

THE application of this to what happens in siphons is obvious enough. For, when once the water is brought to run through a siphon, the air (which is a fluid, and has some gravity, and has no access into the cavity of the siphon) must necessarily gravitate upon the water, whereinto the legs of the siphon are dipped, and not upon that which is within the siphon: and consequently, though the incumbent air have somewhat a greater height upon the water in the lower vessel, than upon that in the upper; yet the gravitation it thereby exercises upon the former more than upon the latter, being very inconsiderable, the water in the longer leg much preponderating (by reason of its length) the water in the shorter leg, the efflux must be out of that leg, and not out of the other. And the pressure of the external air being able to raise

raise water (as we find by sucking pumps) to a far greater height, than that of the shorter leg of the siphon; the efflux will continue, for the same reason, till the exhaustion of the water, or some other circumstance, alter the case. But, if the legs of the siphon should exceed thirty four or thirty five foot of perpendicular altitude, the water would not flow through it; the pressure of the external air being unable (as has been elsewhere declared) to raise water to such a height. And if a hole being made at the top of a siphon, that hole should be unstopped, while the water is running, the course of it would presently cease. For, in that case, the air would gravitate upon the water, as well within as without the cavity of the siphon; and so the water in each leg would, by its own weight, fall back into the vessel belonging to it.

In the
Physico-
mechanical
Experi-
ments.

BUT because this last circumstance, though clearly deducible from hydrostatical principles and experiments, has not, that I know of, been verified by particular trials, I caused two siphons to be made, the one of tin, the other of glass; each of which had, at the upper part of the flexure, a small round hole or socket, which I could stop and unstop, at pleasure, with the pulp of my finger. So that, when the water was running through the siphon, in case I removed my finger, the water would presently fall, partly into one of the subjacent vessels, and partly into the other. And if the legs of the siphon were so unequal in length, that the water in the one had a far greater height (or depth) than in the other; there seemed to be, when the liquor began to take its course through the siphon, some light pressure from the external air upon the finger, wherewith I stopped the orifice of the socket made at the flexure.

AND on this occasion I will add, what I have more than once tried; to shew, at how very minute a passage the pressure of the external air may be communicated to bodies fitted to receive it. For, having for this purpose stopped the orifice of one of the above mentioned siphons, (instead of doing it with my finger) with a piece of oiled paper, carefully fastned with cement to the sides of the socket; I found, as I expected, that though hereby the siphon was so well closed, that the water ran freely through, yet, if I made a hole with the point of a needle, the air would at so very little an orifice insinuate itself into the cavity of the siphon, and, thereby gravitating as well within as without, make the water in the legs to fall down into the vessels. And though, if I held the point of the needle in the hole I made, and then caused one to suck at the longer leg; this small stopple, without any other help from my hand, sufficed to make the siphon fit for use: yet if I removed the needle, the air would (not without some noise) presently get in at the hole, and put a final stop to the course of the water. Nor was I able to take out the needle, and put it in again so nimbly, but that the air found time to get into the siphon; and, till the hole were again stopped, rendered it useless, notwithstanding that the water was by suction endeavoured to be set a running.

P A R A D O X X I.

That a solid body, as ponderous as any yet known, though near the top of the water, it will sink by its own weight; yet if it be placed at a greater depth than that of twenty times its own thickness, it will not sink, if its descent be not assisted by the weight of the incumbent water.

THIS paradox having never been (that I know of) proposed as yet by any, has seemed so little credible to those to whom I have mentioned it, without excepting mathematicians themselves) that I can scarce hope it should be readily and generally

rally received in this illustrious company, upon less clear testimony, than that of experience. And therefore, though (if I mistake not) some part of this proposition may be plausibly deduced by the help of an instrument ingeniously thought upon by Monsieur *Pascal*; yet I shall have recourse to my own method for the making of it out, for these two reasons: the one, that a great part of the paradox must be explicated, as well as proved, by the doctrine already settled in this paper; the other, that the experiment proposed by Monsieur *Pascal*, being to be done in a deep river, and requiring a tube twenty foot long, whose bottom must be fitted with a brass cylinder, made with an exactness, scarce (if at all) to be hoped for from our workmen; if I should build any thing on this so difficult an experiment, (which himself does not affirm to have ever been actually tried) I fear most men would rather reject the experiment as a chimerical thing, than receive for its sake a doctrine that appears to them very extravagant.

Fig. XIX.

LET us then, to employ in this case also the method we have hitherto made use of, fill a glass vessel, A B C D, almost full of water; only, in regard that there is a great depth of water requisite to some circumstances of the experiment, this last must not be so shallow, as those hitherto employed: but a deep cylinder or tube, sealed at one end, whose depth must be at least two or three foot, though its breadth need not be above two or three inches; and, to keep it upright, it may be placed in a socket of metal, or wood, of a size and weight convenient for such a purpose. This glass being thus fitted in water, let us suppose E F to be a round and flat piece of solid brass, having about an inch in diameter, and a fourth, or sixth part of an inch in thickness. This cylinder, being immersed under water, till it be just covered by the uppermost surface of that liquor, and being let go, must necessarily fall downwards in it; because, if we suppose the imaginary superficies G H to pass along the circle F, which is the lower part of the brass body, that metal being *in specie* far heavier than water, the brass, that leans upon the part F, must far more gravitate upon the said part F, than the incumbent water does upon any other part of the superficies G H; and, consequently, the subjacent water at F will be thrust out of place by the descending body. And because that, in what part soever of the water, not exceeding nine times its thickness, measured from the top of the water A C, the ponderous body E F shall happen to be; there will be still, by reason of the specific gravity of the metal, a greater pressure upon that part of the imaginary superficies, that passes along the bottom of the body, on which the part F shall happen to lean, than upon any other part of the same imaginary superficies; the brass body would still descend by virtue of its own weight, though it were not assisted by the weight of the water, that is over it. But let us suppose it to be placed under water on the designable plane J K; and let this plane, which (as all other imaginary planes) is, as well as the real surface of the water, to be conceived parallel to the horizon; and let the depth, or distance of this plane, from the uppermost surface of the water, be (somewhat) above nine times the thickness of the brass body: I say, that, in this case, the body would not descend, if it were not pressed downwards by the weight of the water it has over it. For, brass being but about nine times * as heavy as water of an equal bulk to it, the body E F alone would press upon the part F, but as much as a cylinder of water would, which, having an equal basis, were eight or nine times as high, as the brass is thick. But now, all the other parts of the imaginary surfaces I K being pressed upon by the incumbent water, which is as

* The word, *about*, is added, because indeed the author, - as he elsewhere delivers, did, by exact scales, find brass to weigh between eight and nine times as much as water; but judged it needless to his present argument, and inconvenient, to take notice of the fraction.

high above them, as the newly mentioned cylinder of water would be; there is no reason, why the part F should be depressed, rather than any other part of the superficies J K: but because it is true, which we formerly taught, namely, that water retains its gravity in water; and that too, though a body, heavier *in specie* than it, be placed immediately under it; it will necessarily happen, that in what part soever the solid body be placed, provided it be every way environed with the water, it must, for the reason newly given, be made to move downwards, partly by its own weight, and partly by that of the incumbent water; and must continue to sink, till it come to the bottom, or some other body, that hinders its farther descent.

BUT in case the water above the solid body did not gravitate upon it, and thereby assist its descent; or in case, that the incumbent water were, by some artifice or other, so removed, that none of the lateral water (if I may so call it) could succeed in its place to lean upon the solid; then it will follow, from what we have newly shown, that the solid would be kept suspended. And in case it were placed much deeper in the water, as over-against the point L, or M; then, if we conceive the incumbent water to be removed, or fenced off from it, the pressure of the solid alone upon the part F, of the imaginary superficies L M, being very much inferior to that of the water upon the other parts of the same surface, the part F would be strongly impelled upwards, by a force proportionate to the difference of those two pressures. And therefore, since I have found by trials, purposely made in scales marvellously exact, and with refined gold, (purer than, perhaps, any that was ever weighed in water) that gold, though much the ponderoufest of bodies yet known in the world, is not full twenty times as heavy, as water of the same bulk; I kept within compass, (as well as employed a round number, as they call it) when I said, that no body (yet known) how ponderous soever, will subside in water by its own weight alone, if it were so placed under water, that the depth of the water did above twenty times exceed the height of the body; not to mention here, that, though gold and water being weighed in the air, their proportion is above nineteen to one, yet, in the water, gold does, as other sinking bodies, lose as much of its weight, as that of an equal bulk of water amounts to.

I WAS saying just now, that, in case the brazen body were placed low enough beneath the surface of the water, and kept from being depressed by any incumbent water, it would be supported by the subjacent water. And this is that very thing, that I am now to shew by an experiment.

LET then the brass body E F be the cover of a brass valve, (as in the annexed figure) and let the valve be fastened with some strong and close cement to a glass pipe, O P, (open at both ends) and of a competent length and wideness. For then the body E F, being the undermost part of the instrument, and not sticking to any other part of it, will fall by its own weight, if it be not supported. Now then, tying a thread to a button Q, (that is wont to be made in the middle of the doors of brass valves) you must, by pulling that string straight and upwards, make the body E F shut the orifice of the valve as close as you can; (which is easily and presently done.) Then, thrusting the valve under water, to the depth of a foot, or more, the cement and the sides of the glass O P, (which reaches far above the top of the water X Y) will keep the water from coming to bear upon the upper part of the body E F; and consequently, the imaginary surface V W, (that passes by the lower part of the said body) will, where it is contiguous thereunto, be pressed upon only by the proper weight of the body E F; but, in its other parts, by the much greater weight of the incumbent water. So that, though you let go the string, (that held the body E F

Fig. XX.

close to the rest of the instrument) the said body will not at all sink, though there be nothing but water beneath it to support it.

AND to manifest, that it is only the pressure of the water, of a competent depth, that keeps the solid suspended; if you slowly lift up the instrument towards (X Y) the top of the water; you shall find, that, though for a while the parts of the valve will continue united, as they were before; yet, when once it is raised so near the surface, (as between the plane I K and X Y) that the single weight of E F, upon the subjacent part of the imaginary plane, that passes by it, is greater than the pressure of the incumbent water upon other parts of the same plane; that body, being no more supported as formerly, will fall down, and the water will get into the pipe, and ascend therein to the level of the external water.

BUT if, when the valve is first thrust under water, and before you let go the thread, that keeps its parts together, you thrust it down to a good depth, as to the superficies R S; then, though you should hang a considerable weight, as L, to the valve E F, (as I am going to shew you a trial with a massy cylinder of stone broader than the valve, and of divers inches in length) the surplussage of pressure on the other parts of the plane V W, (now in R S) over and above what the weight of the body E F, and that of the cylindrical stone L to boot, can amount to, on that part of the surface, which is contiguous to the said body E F, will be great enough to press so hard against the lower part of the valve, that its own weight, though assisted with that of the stone, will not be able to disjoin them.

By which (to note that by the way) you may see, that though, when two flat and polished marbles are joined together, we find it is impossible to sever them without force; we need not have recourse to a *fuga vacui* to explicate the cause of their cohesion, whilst they are environed by the air, which is a fluid not devoid of gravity, and reaching above the marbles, no body knows how high.

AND, to evince, that it is only such a pressure of the water, as I have been declaring, that causes the cohesion of the parts of the valve; if you gently lift it up towards the top of the water, you will quickly find the brass body E F drawn down by the stone (L) that hangs at it; as you will perceive by the water's getting in between the parts of the valve, and ascending into the pipe.

To which I shall only add, what you will quickly see, that, in perfect conformity to our doctrine, the pressure of the body E F, upon the subjacent water, being very much increased by the weight of the stone, that hangs at it, the valve needs not, as before, be lifted up above the plane J K, to overcome the resistance of the water, being now enabled to do it, before it is raised near so high.

APPENDIX I.

Containing an answer to seven objections, proposed by a late learned writer, to evince, that the upper parts of water press not upon the lower.

AFTER I had, this morning, made an end of reviewing the foregoing papers, there came into my hands some questions lately published, among other things, by a very recent writer of Hydrostaticks. In one of which questions, the learned author strongly defends the contrary to what has there been in some places proved, and divers places supposed.

THE author of these Erotemata asserts, that, *in consistent water, the upper parts do not gravitate, or press upon the lower.*

AND therefore, I think it will be neither useless, nor improper, briefly to examine here the arguments he produces. Not useless; because the opinion he asserts both is, and

and has long been, very generally received; and because too it is of so great importance, that many of the erroneous tenets and conclusions of those, that (whether professedly, or incidentally) treat of hydrostatical matters, are built upon it. And not improper; because our learned author seems to have done his reader the favour to sum up into one page all the arguments for his opinions, that are dispersedly to be found in his own, or other mens books. So that, in answering these, we may hope to do much towards a satisfactory decision of so important a controversy. And, after what we have already delivered, our answers will be so seasonable, that they will not need to be long; the things they are built on having been already made out in the respective places, whereto the reader is referred.

Our author then maintains, that, in consistent water, the superiour do not actually press the inferiour parts, by the seven following arguments.

Object. 1. SAYS he, *Because else the inferiour parts of the water would be more dense than the superiour, since they would be compressed and condensed by the weight of them.*

Ans. BUT, if the corpuscles, whereof water consists, be supposed to be perfectly solid and hard, the inferiour corpuscles may be pressed upon by the weight of the superiour, without being compressed, or condensed by them; as it would happen, if diamond-dust were laid together in a tall heap: for, though the upper parts, being heavy and solid corpuscles, cannot be denied to lean, and press upon the lower; yet these, by reason of their adamantine hardness, would not be thereby compressed. And it is possible too, that the corpuscles of water, though not so perfectly hard, but that they may a little yield to an extreme force, be solid enough not to admit from such a weight, as that of the incumbent water, (at least in such small heights, as observations are wont to be made in) any compression great enough to be sensible; as, besides some trials I have formerly mentioned in another place, those, made in the presence of this illustrious company, seem sufficiently to argue; viz. that water is not sensibly compressible by an ordinary force. And I find not, by those, that make the objection, that they ever took pains to try, whether, in deep places of the sea, the lower parts are not more condensed than the upper; nor do I see any absurdity, that would follow from admitting them to be so.

Object. 2. OUR author's second argument is, *Because divers feel not, under water, the weight of the water, that lies upon them.*

Ans. BUT, for answer to this argument, I shall content myself to make a reference to the ensuing appendix, where this matter will be considered at large; and where, I hope, it will be made to appear, that the phenomenon may proceed, partly from the firm texture of the diver's body, and partly from the nature of that pressure, which is exercised against bodies immersed in fluids; which, in that case, (as to sense) presses every where equally against all the parts of the body exposed to their action.

Object. 3. THE third argument is, *That even the slightest herbs, growing at the bottom of the water, and shooting up in it to a good height, are not oppressed, or laid by the incumbent water.*

Ans. BUT the answer to that is easy, out of the foregoing doctrine. For the plants, we speak of, sustain not the pressure of the water above them by their own strength, but by the help of the pressure of water, that is beneath: which, being itself pressed by the water, that is (though not perpendicularly over it) superiour to it, presses them upwards so forcibly, that, if they were not by their roots, or otherwise, fastened to the ground, they, being *in specie* lighter than water, would be buoyed up to the top of the

the water, and made to float; as we often see that weeds do, which storms, or other accidents, have torn from their native soil.

Object. 4. A FOURTH objection is this; *That a heavy body, tied to a string, and let down under water, is supported, and drawn out with as much ease, as it would be, if it had no water incumbent on it; nay, with greater ease, because heavy bodies weigh less in water, than out of it.*

Ans. BUT an account of this is easy to be rendered out of our doctrine; for, though the water incumbent on the heavy body do really endeavour to make it sink lower, yet that endeavour is rendered ineffectual to that purpose by the equal pressure of the water upon all the other parts of the imaginary surface, that is contiguous to the bottom of the immersed body. And that pressure upon the other parts of that supposed plane being equal, not only to the pressure of the pillar of water, but to that pillar, and to the weight of as much water, as the immersed body fills the place of; it must needs follow, that not only the hand, that sustains the body, should not feel the weight of the incumbent water, but should be able to lift up the body more easily in the water, than in the air. But, though the pressure of the water incumbent on the stone cannot, for the reason assigned, be felt in the case proposed; yet, if you remove that water, (as in the experiment brought for the proof of the last paradox) it will quickly appear by the pressure against the lower part of the heavy body, and its inability to descend by its own weight, when it is any thing deep under water; it will, I say, quickly appear, by what will follow upon the absence of the incumbent water, how great a pressure it exercised upon the stone, whilst it leaned on it.

Object. 5. THE fifth argument is proposed in these words; *Because a bucket full of water is lighter in the water, than out of it; nor does weigh more, when full within the water, than when empty out of it; nay, it weighs less, for the reason newly assigned, (in the fourth objection) therefore the water of the bucket, because it is within water, does not gravitate, nor, consequently, press downwards either the bucket, or the water under the bucket.* This is the grand and obvious experiment, upon which the schools, and the generality of writers have very confidently built this axiom, *That the elements do not gravitate in their proper place;* and particularly, that water weighs not (as they speak) in its own element.

Ans. WHAT they mean by *proper*, or *natural place*, I shall not stand to examine; nor to inquire, whether they can prove, that water, or any other sublunary body possesses any place, but upon this account, that the cause of gravity, or some other movent, enables it to expel other contiguous bodies (that are less heavy, or less moved) out of the place they possessed before; and gives it an incessant tendency, or endeavour towards the lowermost parts of the earth.

BUT, as to the example proposed, it is very easy to give an account of it; for, suppose A B C D to be a well, wherein, by the string E F, the bucket is suspended under water, and has its bottom contiguous to the imaginary plane I K: if now we suppose the bucket to consist only of wood lighter than water, it will not only not press upon the hand, that holds the rope at E, but will be buoyed up, till the upper parts of the bucket be above the top of the water; because the wood, whereof the bucket is made, being lighter in *specie* than water, the pressure of the water in the bucket G, and the rest of the water incumbent on that, together with the weight of the bucket itself, must necessarily be unable to press the part H so strongly, as the other parts of the imaginary plane I K are pressed by the weight of the meer water incumbent on them. But if, as it is usual, the bucket consists partly of wood, partly of iron; the aggregate may often indeed be heavier than an equal bulk of water: but then the hand, that draws up the bucket by the rope F E, ought not, according to our doctrine,

doctrine, to feel the weight of all the bucket, much less that of the water contained in it. For though that aggregate of wood and iron, which we here call the bucket, be heavier than so much water; yet it tends not downwards with its whole weight, but only with that surplufage of weight, whereby it exceeds as much water, as is equal to it in bulk; which surplufage is not wont to be very considerable. And as for the water in the cavity G of the bucket, there is no reason, why it should at all load the hand at E, though really the water, both in the bucket and over it, do tend downwards with their full weight; because that the rest of the water L I, and M K, do full as strongly press upon the rest of the imaginary superficies I K, as the bucket and the incumbent water do upon the part H; and consequently, the bottom of the bucket is every whit as strongly pressed upwards by the weight of the water upon all the other parts of the plane I K, as it tends downwards by virtue of the weight of the incumbent water, that is partly in the bucket, and partly above it; and so, these pressures balancing one another, the hand, that draws the rope at E, has no more to lift up, than the surplufage of weight, whereby the empty bucket exceeds the weight of as much water, as is equal in bulk (I say not to the bucket, as it is a hollow instrument, but) to the wood and iron, whereof the bucket consists.

AND because this example of the lightness of filled buckets within the water has for so many ages gained credit to, if it have not been the only ground of, the assertion, that water weighs not in its own element, or in its proper place; I shall add. (though I can scarce present it to such a company as this without smiles) an experiment, that I made to convince those, that were, through unskilfulness or prejudice, indisposed to admit the hydrostatical account I have been giving of the phenomenon. I took then a round wooden box, which I substituted in the room of a bucket; and (having filled it with melted butter, into which, when it was congealed, some small bits of lead were put, to make it a little heavier than so much water) I caused a small string of twined silk to pass through two small holes, made in the opposite parts of the upper edge of the box, and to be suspended at one end of the beam of a pair of goldsmiths scales; and then putting it into a vessel full of water, till it was let down there, to what depth I pleased, it appeared, that not only the least endeavour of my hand would either support it, or transport to and fro in the water, or draw it up to the top of it; and this, whether the box were made use of, or whether the butter and lead alone, without the box, were suspended by the silken string: but (to evince, that it was not the strength of my hand, or the smallness of the immersed body, that kept me from feeling any considerable resistance) I cast some grains into the scale, that hung at the other end of the above mentioned beam, and presently raised the lead and butter to the surface of the water. So that, unless the schoolmen will say, that the butter and lead were in their own element, we must be allowed to think, that the easy sustentation, and elevation of the box, did not proceed from hence, that those bodies weighed not, because they were in their natural place. And yet in this case, the effect is the same with that, which happens, when a bucket is drawing out of a well.

AND, to manifest that it was the pressure of the water against the lower part of the surface of our suspended body, that made it so easy to be supported in the water, or raised to the top of it; I shall add, that though a few grains sufficed to bring the upper surface of the butter to the top of the water, yet afterwards there was a considerable weight requisite to raise more and more of its parts above the water's surface; and a considerabler yet, to lift the whole body quite out of the water. Which is very consonant to our doctrine. For, suppose the bucket to be at the part N, half in and half

out

out of the water : the hand or counterpoise, that supports it in that posture, must have a far greater strength than needed to sustain it, when it was quite under water ; because that now the imaginary plain PQ , passing by the bottom of the bucket, has on its other parts but a little depth of water, as from L to P , or M to Q ; and consequently the bottom of the bucket, H , will scarce be pressed upwards above half as strongly as when the bucket was quite under water. And if it be raised to O , and consequently quite out of the water ; that liquor reaching no longer to the bottom of the bucket, can no longer contribute to its supportation ; and therefore a weight not only equal, but somewhat superiour to the full weight of the bucket, and all that it contains (being all supposed to be weighed in the air) will be necessary to lift it clear out of the water.

BUT to dwell longer on this subject cannot but be tedious to those, that have been any thing attentive to the former discourses. I proceed therefore to our author's sixth argument, which is,

Object. 6. That horse-hairs, which are held to be of the same gravity with water, keep whatever place is given them in that liquor ; nor are depressed by the weight of the super-incumbent water.

Ans. Whether the matter of fact be strictly and universally true, is scarce worth the examining, especially since we find the difference in point of specifick gravity, betwixt most horse-hairs, and most waters, to be inconsiderable enough. But the phenomenon, supposing the truth of it, is very easily explicable, according to the doctrine above delivered. For supposing in the last scheme the body, R , to be bulk for bulk exactly equiponderant to water ; it is plain there is no reason, why that body should press the part S , of the imaginary superficies IK , either more or less than that part S would be pressed, if the body R being annihilated or removed, it were succeeded by a parcel of water of just the same bulk and weight. And consequently, though all the water directly above the solid R do really lean upon that body, and endeavour to depress it ; yet that endeavour being resisted by an equal and contrary endeavour, that proceeds (as we have been but too often fain to declare) from the pressure exercised upon the other parts of the superficies, IK , by the water incumbent on them ; the body R will be neither depressed nor raised. And its case being the same in what part of the water soever it be placed, provided it be perfectly environed with that liquor ; it must keep in the water (which in this whole discourse we suppose to be homogeneous as to gravity) the place you please to give it.

AND (to add that, on this occasion) though mathematicians have hitherto contented themselves to prove, that in case a body could be found or provided, that were exactly equiponderant to water, it would retain any assignable place in it ; yet the curiosity we had, to give an experimental proof of this truth, at length produced some glass-bubbles, which some gentlemen here present have not perhaps forgot, that were (by a dextrous hand we employed about it) so exquisitely poised, as, to the wonder of the beholders, to retain the places given them, sometimes in the middle, sometimes near the top, and sometimes near the bottom of the water (though that were homogeneous) for a great while, till some change of consistence or gravity in the water, or some of its parts, made the bubble rise or fall.

THE application of this to what has been objected concerning horse-hairs, being too easy to need to be insisted on, there remains to be dispatched our author's seventh and last argument, which is this :

Object. 7. That, otherwise, all the inferiour parts of the water would be in perpetual motion, and perpetually expelled by the superiour.

Ans.

Anfw. But if, by the inferiour parts, he means such portions, as are of any considerable bulk; the answer newly made to the last objection (where we shewed, that the body, R, would retain its place any where in the water, and consequently near the bottom) will shew the invalidity of this objection. And unless we knew of what bigness and shape the corpuscles of water are, it would perhaps be to little purpose to dispute, how far it may be granted, or may be true in the particles, that water is made up of. Only this I shall add, that, whereas this learned author mentions it as an absurdity, that the lower parts of water should be in perpetual motion; and *Stevinus* himself, in the beginning of his hydrostatical elements, seems to me to speak somewhat inconsiderately of this matter; and though, as I lately said, I allow such sensible bodies, as those, whose gravity in water writers are wont to dispute of, to be capable of retaining their places in water, if they be *in specie* equiponderant to it: yet I am so far from thinking it absurd, that the inferiour corpuscles of water should be perpetually in motion, that I see not how otherwise they could constitute a fluid body, that restless motion of their parts being one of the generalest attributes of liquors; and being, in water, though not immediately to be seen, yet to be easily discovered by its effects: as, when salt, being cast into water, the aqueous parts, that are contiguous to it, and consequently near to the bottom, do soon carry up many of the saline ones to the very top of the water; where, after a while, they are wont to disclose themselves in little floating grains of a cubical shape.

BUT of this restless motion of the parts of liquors having professedly treated elsewhere already; I shall add nothing at present, but rather take notice of what our author subjoins to the last of his arguments, (as the grand thing which they suppose) in these words: *Ratio porro, à priori, hujus sententiæ videtur esse, quia res non dicitur gravitare, nisi quatenus habet infra se corpus levius se in specie.* The erroneousness of which conceit if I should now go about solemnly to evince, I as well fear it would be tedious, as I hope it will be needless to those, that have not forgot what may concern this subject in the former part of the now at length finished discourse; and especially where I mention those experiments, which show, that neither a stone, nor gold itself, when placed deep under water, would sink in it, if the superiour water, that gravitates on it, did not contribute to its depression.

In the history of fluidity and firmness.

APPENDIX II.

Concerning the reason, why divers, and others, who descend to the bottom of the sea, are not oppressed by the weight of the incumbent water.

AMONGST the difficulties, that belong to the Hydrostaticks, there is one, which is so noble, and which does still so much both exercise and pose the wits of the curious, that perchance it will not be unacceptable, if to the former experiments we add, by way of appendix, one, that may conduce to the solving of this difficult problem; *viz.* why men, deep under water, feel no inconvenience by the pressure of so great a weight of water as they are placed under?

THE common answer of philosophers and other writers to this puzzling question is, that the elements do not gravitate in their own proper places; and so, water in particular has no gravitation upon water, nor consequently upon bodies every way surrounded with water. But that this solution is not to be admitted, may be easily gathered from our proofs of the first paradox, and from divers other particulars, applicable to the same purpose, that may be met with in the foregoing papers.

A FAMOUS writer, and, for aught I know, the recentest (except *Monsieur Pascal*) that has treated of Hydrostaticks, having rendered this reason of the phenomenon:

[The superiour parts of consistant water (as he speaks) press not the inferiour, unless beneath the inferiour there be a body lighter in specie than water; and therefore, since a human body is heavier in specie than water, it is not pressed by the incumbent water, because this does not endeavour to be beneath a human body] He subjoins, contrary to his custom, this confident epiphonema, *Quia aliam causam hujus rei assignant, errant, & alios decipiunt.*

BUT, by his favour, notwithstanding this confidence, I shall not scruple to seek another reason of the phænomenon. For I have abundantly proved, that (contrary to the assertion on which his explication is built) the upper parts of water press against the lower, whether a body heavier or lighter *in specie* than water be underneath the lower. And, the contrary of which being the *πρῶτον λεγόμενον* in this controversy, perhaps the matter may be somewhat cleared, by mentioning here a distinction, which I sometimes make use of. I consider then a body may be said to gravitate upon another body in two senses. For sometimes it actually sinks into, or gets beneath the body, that was under it, as a sinking stone gravitates upon water, and which I call prevalent, or successful gravitation; and sometimes it does not actually, at least not visibly descend, but only exercises its gravitation by pressing against the subjacent body that hinders its descent: as when a woman carries a pail of water on her head, though the weight do not actually get nearer the center of the earth; yet it actually presses with its whole gravity upon the woman's head, and back, and other subjacent parts, that hinder its actual descent. And, according to this doctrine, I cannot admit our author's reasoning, that because a man's body is bulk for bulk heavier than water, therefore the water does not endeavour to place itself beneath it. For water, being a heavy body, derives from the cause of its gravity (whatever that be) an incessant endeavour towards the center of the earth; nor is there any reason, why its happening to be incumbent on a body heavier *in specie* than itself, should destroy that endeavour. And therefore, though it may be said, that the water does not endeavour to place itself beneath a human body, because indeed an inanimate liquor cannot properly be said to act for this or any other end; yet the water being a heavy body, tends continually towards the lower part of the earth; and therefore will get beneath any body that is placed betwixt it and that, (without regard whether the inferiour body be heavier or lighter *in specie* than itself) as far as the degree of its gravity will enable it; nor would it ever rest, till it have reached the lowermost parts of the earth, if the greater ponderousness of the earth, and other heavy bodies, did not hinder, (not its endeavour downwards, nor its pressure upon subjacent bodies, but only) its actual descent.

THIS learned author himself tells us, (as well as *Stevinus*, and others, that have written of the Hydrostaticks, unanimously teach) that if the bottom of a vessel be parallel to the horizon, the weight of water, that rests upon it, is equal to a pillar of water, having that bottom for its basis, and for its height a perpendicular reaching thence to the uppermost surface of the water. Nor is it reasonable to conceive, that there will be any difference in this pressure of the incumbent water, whether the bottom be of deal, that will swim, or of box, that will sink in water; or, to speak more generally, whether it be of wood, *in specie* lighter than water, or of copper, or some other metal, that is *in specie* heavier than it. And since water, being not a solid body, but a fluid, consists (as other fluids) of innumerable corpuscles, that, though extremely minute, have their own sizes and figures; and since the pressure of water upon the bottom of a vessel is proportionate to its perpendicular height over the bottom; it is manifest, that the upper corpuscles press the bottom as well as the lower; which since they cannot do immediately, they must do by pressing the intermediate

mediate ones. And I have already shown (discourfing one of the former paradoxes) that the fuperiour parts of water do not only prefs thofe, that are directly under them, but communicate a preffure to thofe, that are afide of them, and at a diftance from them.

AND if it be objected, that water endeavours to get beneath a bottom of glafs-veffels, or other bodies heavier *in fpecie* than itfelf, becaufe under that bottom there is air, which is a lighter body *in fpecie* than water: I fay, that this is precarious; for the indifputable gravity of the water is alone fufficient to make it always tend downwards, (though it cannot always move downwards) whatever body be beneath it. And who can affure the makers of this objection, that there are not beneath even the bottom of rivers, or of the fea, (where yet they fay water is confiftent, and refts as in its own place) vaft fpaces replenifhed but with air, fumes, or fire, or fome other body lighter than water? For, (not to mention, that the Cartefians take the earth we tread on, to be but a thin cruft of the terreftrial globe, whofe infide, as far as the center, is replenifhed with a fubtile fluid matter, like that whereof the fun confifts) we know that in fome places, as particularly at a famous coal-mine in *Scotland*, there are great cavities, that reach a good way under that ground, that ferves there for a bottom to the fea: fo that, for aught thefe objectors know, even according to their own doctrine, the water, even in the fea, may endeavour to get beneath a body heavier *in fpecie* than itfelf.

BUT, for my part, I cannot but think, that, to imagine the water knows, whether or no there be air or fome lighter body than itfelf beneath the body it leans on, and the fuperiour parts do accordingly exercife or fufpend their preffure upon the inferiour; is to forget that it is a heavy liquor, and an inanimate body.

ANOTHER folution there is of this hydroftatical problem we have been discourfing of, which I met with in a printed letter of *Monfieur Des Cartes*, in thefe terms:

Je ne me, &c. I remember not what reason it is, that Stevinus gives, why one feels not the weight of water, when one is under it: but the true one is, that there can no more of water gravitate upon the body, that is in it, or under it, than as much water as could defcend in cafe that body left its place. Thus, for example, if there were a man in the barrel B, that fhould with his body fo flop the hole A, as to hinder the water's getting out, he would feel upon himfelf the weight of the whole cylinder of water ABC, of which I fuppofe the bafis to be equal to the hole A: forasmuch as if he funk down through the hole, all the cylinder of water would defcend too; but if he be a little higher, as about B, fo that he does no longer hinder the water from running out at the hole A, he ought not to feel any weight of the water which is over him, betwixt B and C; becaufe if he fhould defcend toward A, that water would not defcend with him, but contrariwife a part of the water, which is beneath him towards A, of equal bulk to his body would afcend into its place: fo that, inftead of feeling the water to prefs him from the top downward, he ought to feel, that it buoys him upward from the bottom; which by experience we fee.

THUS far this fubtile philofopher; for whofe ratiocinations though I am wont to have much refpect, yet I muft take the liberty to confeß myfelf unfatisfied with this. For, having already fufficiently proved, that the upper parts of water prefs the lower, and the bodies placed beneath them, whether fuch bodies be lighter *in fpecie* than water, or heavier; we have fubverted the foundation, upon which *Monfieur Des Cartes's* ingenious, though unfatisfactory, explication is built. And yet I fhall add, *ex abundanti*, that fuppofing what he fays, that, in cafe the folid B fhould defcend towards A, the incumbent water would not defcend with it, but a part of the fub-jacent water, equal in bulk to the folid, would afcend, and fucceed in its room; yet

that is but accidental, by reason of the staunchness and fulness of the vessel. And though, indeed, the superiour water cannot actually descend upon the depression of the solid at B, if at the same time, while that body descends, an equal bulk of water succeeds in its place; yet both the solid about C, and the water, that succeeds it, do, in their turns, hinder the descent of the superiour water; which therefore must gravitate upon which soever of the two it be, that actually comes to be placed directly under it, if there be nothing before the displacing of the solid capable to take away the natural gravity, upon whose account the water over B and C does incessantly tend downwards. And though Monsieur *Des Cartes* does not so clearly express himself, whether he supposes the hole at A to be stopped with some other body, when the solid is placed about B; yet, because he is wont to speak consistently, I presume he means, that, when the solid is removed to B, the hole at A is otherwise sufficiently stopped; I say then, that the reason, why the solid, which, whilst at A, sustained a great pressure from the incumbent water, feels not the weight of it, when placed at B, is not that, which Monsieur *Des Cartes* gives, but this; That the solid being environed with water, the subjacent water does (as we have often had occasion to manifest) press it upwards full as strongly (and somewhat more) as the weight of the incumbent water presses it downwards; so that a man's body, instead of sinking, would be buoyed up, if, as it is a little heavier, it were a little lighter *in specie* than water. Whereas, when the solid was that alone, which covered and stopped the hole, there was a manifest reason, why it should be forcibly thrust downwards by the weight of the incumbent water B C. For, in that case, there was no water underneath it at A, to support the solid; and, by its pressure, to enable it to resist so great a weight.

AND this (to hint that upon the by) may, perchance, help us to guess at the reason of what geographers relate of the lake *Asphaltites* in *Judea*, (in case the matter of fact be true) that this *Dead Sea* (as they also call it) will not suffer any living creature to sink in it. For the body of a man (and, for aught we know, of other animals) is not much heavier *in specie* than common fresh water. Now, if in this lake (that stands, where *Sodom* and *Gomorrab* did, before those impious regions were destroyed by fire from heaven) we suppose, (which the nature of the soil, and the sacred story makes probable enough) that the water abounds with saline, or sulphureous corpuscles; (the former helping the latter to associate with the water, as we see in soap consisting of salt and oil, and in chymical mixtures of alcalis and brimstone dissoluble in water) the liquor may have its gravity so augmented, as to become heavier *in specie* than the body of an animal. For I have learned of a light swimmer, that he could hardly begin to dive in salt water, though he easily could in fresh. And it is not difficult to make a brine or lixivium (which are but solutions of salt in water) heavy enough to keep up an egg from sinking. And not only barely by dissolving a metalline body in a saline *menstruum*, without otherwise thickening the liquor, I have brought solid pieces of amber itself to swim upon it; but I have tried, that certain saline solutions, which I elsewhere mention, nay, and a distilled liquor, (I used deslegmed oil of vitriol) without any thing dissolved in it, would do the same thing, by reason of the numerous, though minute, corpuscles of salt and sulphur, that it abounds with.

THERE remains but one solution more of our hydrostatical problem, that I think worth mentioning, and that is given by the learned *Stevinus* in these words:

OMNI pressu, quo corpus dolore afficitur, pars aliqua corporis luxatur; sed isto pressu nulla corporis pars luxatur; isto igitur pressu corpus dolore nullo afficitur. Assumptio syllogismi manifesta est; nam si pars aliqua, ut caro, sanguis, humor, aut quodlibet denique

*membrum luxaretur, in alium locum concedat necesse esset: atqui locus ille non est extra corpus; cum aqua undiquaque equali pressu circumfusa sit (quod vero pars ima, per undecimam propositionem Hydrostaticorum, paulo validius prematur superiori, id hoc casu nullius momenti est, quia tantula differentia partem nullum sua sede dimovere potest) neque item intra ipsum corpus concedit, cum istic corpore omnia oppleta sint, unde singula partes singulis partibus aequaliter resistunt, namque aqua undiquaque eadem ratione corpus totum circumstat. Quare cum locus is nec intra, nec extra corpus sit; absurdum, imo impossibile fuerit, partem ullam suo loco emovere, ideoque nec corpus hic afficitur dolore.**

THIS solution of *Stevinus* I esteem preferable by far to those, that are wont to be given of this difficult problem: but yet the phenomenon seems to me to have still somewhat in it of strange. It is true, that if the question were only that, which some put, viz. Why the body of a diver, when it is near the bottom of the sea, is not pressed down by so vast a weight of water, as is incumbent on it? it might be rationally answered, That the weight of so much water, as leans upon the body, is not sustained by the force of the body itself, but by that of the water, which is under it. For, by the experiments and explications, we have annexed to some of the foregoing paradoxes, it appears, that the subjacent water, by its pressure upwards, is able, not only to support the weight of the incumbent water, but so far to exceed it, that it would not only support the immersed body, and the incumbent water, but buoy up the body, if it were never so little lighter *in specie* than water. And as for what *Stevinus* insinuates, that, when the water presses the body every way, that pressure is not felt, though it would be, in case it pressed upon some parts, and not upon others; I am of the same opinion too: and, to prove it, shall not make use of the example he proposes, in the words immediately following those of his I just now recited; (for I doubt, that example is rather a supposition, than a tried thing) but by an experiment, which may be easily made, and has divers times been so, in our pneumatical engine. For, though the air be a heavy fluid, and though, whilst it uniformly presses the whole superficies of the body, we feel not the pressure of it; and though, for this reason, you may lay the palm of your hand upon the open orifice of a small brass cylinder, applied to the engine instead of a receiver, without any hurt: yet when, by pumping, the air, that was before under the palm of your hand, is withdrawn, and consequently can no longer help to support your hand against the pressure of the external and incumbent air, the external air will lean so heavy upon the back of your hand, that you will imagine, some ponderous weight is laid upon it. And I remember, by such an experiment, I have not only had my hand put to much pain, but have had the back of it so bent downward, as if it were going to be broken.

BUT though such considerations, as these, may much lessen the difficulty of our phenomenon, whose cause is inquired into; yet still it seems somewhat odd to me, that (since it is evident from the nature of the thing, and by *Stevinus's* confession, that there is a vast pressure of water against every part of the body, whose endeavour tends inward) so exceedingly forcible a pressure, (which thrusts, for instance, the muscles of the arms and thighs against the bones, and skin and flesh of the thorax against the

* *Stevinus Hydrostat. lib. 5. pag. 149.*

Sed exemplo clarius ita intelliges, esto A B C D aqua, cujus fundum D C, in quo foramen E habeat epistomium sibi insertum, cui dorso incumbat homo F. Quæ cum ita sint, ab aquæ pondere ipsi insidente, nulla pars corporis luxari poterit cum aqua, ut dictum est, undiquaque aequaliter urgeat.

Fig. XXIII.

Si vero ejus veritatem explorare libeat, eximio epistomium, tumque tergum nulla re fultum sustinebitur, ut in locis cæteris, ideoque istic tanto pressu afficietur, quantus tertio exemplo secundæ propositionis hujus demonstratus est: vid. quantum efficit columna aquea, cujus basis sit foramen E, altitudo autem eadem quæ aquæ ipsi insidentis. Quo exemplo propositi veritas manifeste declaratur.

ribs) should not put the diver to any sensible pain; as I find not (by one that I examined) that it does; (though this man told me, he staid a good while at the depth of betwixt eighty and one hundred foot under the sea-water, which is heavier than fresh water:) for, that which *Stevinus's* explication will only show is, that there must be no manifest dislocation of the greater parts of the body; whereas the bare compression of two small parts, one against another, is sufficient to produce a sense of pain.

BUT it seems, the texture of the bodies of animals is better able to resist the pressure of an every way ambient fluid, than, if we were not taught by experience, we should imagine. And therefore, to satisfy those, that (excluding the question about the sense of pain) think it an abundantly sufficient argument, (to prove, that bodies immersed under water, are not compressed by it) that divers are not oppressed, and even crushed by so vast a load of water, (amounting, by *Stevinus's* computation, to many thousands of pounds) as is incumbent on them: we will add, that though an experiment, proposed by Monsieur *Pascal* to this purpose, were such, that at first sight I said, that it would not succeed, (and was not upon trial mistaken in my conjecture;) yet it gave me the occasion to make another, which will, I hope, fully make out the thing I designed it for.

THE ingenious Monsieur *Pascal* would persuade his readers, that if into a glass vessel, with luke-warm water in it, you cast a fly; and, by a rammer, forcibly press that water, you shall not be able to kill, or hurt the fly. Which, says he, will live as well, and walk up and down as lively, in lukewarm water, as in the air. But, upon trial with a strong fly, the animal was (as we expected) presently drowned, and so made moveless, by the lukewarm water.

WHEREFORE we substituted another experiment, that we knew would not only succeed, (as you will presently see it will do) but teach us how great a pressure the included animal must have been exposed to. We took then a somewhat slender cylindrical pipe of glass, sealed at one end, and open at the other; and to this we fitted a rammer, which (by the help of some thongs of soft leather, that were carefully wound about it) did so exactly fill the pipe, that it could not easily be moved to and fro; and would suffer neither water, nor air, to get by betwixt it and the internal surface of the glass. We also provided some small tadpoles (or *Gyrini*) about an inch long or less; which sort of animals we made choice of before any other, partly because they could, by reason of their smallness, swim freely to and fro in so little water as our pipe contained; and partly because those creatures, being as yet but in their infancy, were more tender, and consequently far more exposed to be injured by compression, than other animals of the same bulk, but come to their full age and growth, would be; (as indeed such young tadpoles are so soft and tender, that they seem, in comparison to the bigger sort of flies, to be but organized gelly.) One of these tadpoles being put into the water, and some inches of air being left in the pipe, for the use anon to be mentioned; the water and air, and consequently the tadpole, were by the intrusion of the plug or rammer, with as great a force, as a man was able to employ, violently compressed; and yet, though the tadpole seemed to be compressed into a little less bulk than it was of before, it swam freely up and down the water, without forbearing sometimes to ascend to the very top, though the instrument were held perpendicular to the horizon. Nor did it clearly appear to us, that the little animal was injured by this compression; and most manifest it is, he was not crushed to death, or sensibly hurt by it.

AND having repeated this experiment several times, and with tadpoles of differing ages; we may, I presume, safely conclude, that the texture of animals is so strong, that, though water be allowed to weigh upon water, yet a diver ought not to be oppressed

pressed by it: since, whether or no water weighs in water, it is manifest, that in our experiment, the water, and consequently the tadpole, was very forcibly by an external agent compressed betwixt the violently condensed air, and the rammer. And, by the notice we took of the quantity of air before the compression began, and that to which it was reduced by compression; the moderatest estimate we could make, was, that it was reduced into an eighth, or tenth part of its former space; and so (according to what we have elsewhere proved) the pressure, that was upon the air, (and consequently upon the water, and the included tadpole) was as great, as that of a cylinder of water of above two hundred, if not three hundred foot high. And yet all this weight being unable to oppress, or so much as manifestly to hurt, the tender tadpole, (which a very small weight would suffice to have crushed, if it pressed only upon one part of it, and not upon the other) we may thence learn the truth of what we have been endeavouring to evince: That though water be allowed to press against water, and all immersed bodies; yet a diver may very well remain unoppressed at a great depth under water, as long as the pressure of it is uniform against all the parts exposed thereunto.

A Confirmation of the former * ACCOUNT touching the late EARTHQUAKE near OXFORD, and the Concomitants thereof.

First printed in the *Philosophical Transactions*, N° xi. p. 179.
For April 2, 1666.

AS to the earthquake, your curiosity about it makes me sorry, that, though I think I was the first, that gave notice of it to several of the virtuosi at Oxford; yet the account, that I can send you about it, is not so much of the thing itself, as of the changes of the air, that accompanied it. To inform you of which, I must relate to you, that riding one evening somewhat late, betwixt Oxford and a lodging I have at a place four miles distant from it, the weather having been for a pretty while frosty, I found the wind so very cold, that it reduced me to put on some defensives against it; which I never since, nor, if I forget not, all the foregoing part of the winter was obliged to make use of. My unwillingness to stay long in so troublesome a cold, which continued very piercing, till I had got half way homeward, did put me upon galloping at no very lazy rate; and yet, before I could get to my lodgings, I found the wind turned, and felt the rain falling: which, considering the shortness of the time, and that this accident was preceded by a settled frost, was surprising to me, and induced me to mention it at my return, as one of the greatest and suddenest alterations of air I had ever observed. And what changes I found, have been taken notice of in the gravity of the atmosphere at the same time, by that accurate observer * Dr. Wallis, who then suspected nothing of what followed, as, I suppose, he has ere this told you himself. Soon after, by my guess about an hour, there was a manifest trembling in the house, where I was, (which stands high in comparison of Oxford) but it was not there so great, but that I, who chanced to have my thoughts busied enough on other matters than the weather, should not have taken notice of it as an earthquake, but have imputed it to some other cause, if one, that you know, whose hand is employed in this

* See Num. x. of *Phil. Transactions*, p. 169—171; at the time of the printing whereof, this relation of Mr. Boyle was not yet come to hand.

paper, and begins to be a diligent observer of natural things, had not advertised me of it, as being taken notice of by him, and the rest of the people of the house. And soon after there happened a brisk storm; whereupon I sent to make inquiry at a place called *Brill*, which standing upon a much higher ground, I supposed, might be more obnoxious to the effects of the earthquake, (of which, had I had any suspicion of it, my having formerly been in one near the *Lacus Lemanus* would have made me the more observant) but the person I sent to, being disabled by sickness to come over to me, (which he promised to do, as soon as he could) wrote me only a ticket, whose substance was, That the earthquake was there much more considerable, than where I lodged; and that, at a gentleman's house, whom he names, (the most noted person, it seems, of the neighbourhood) the house trembled very much, so as to make the stones manifestly to move to and fro in the parlour, to the great amazement and fright of all the family. The hill, whereon this *Brill* stands, I have observed to be very well stored with mineral substances of several kinds, and from thence I have been informed by others, that this earthquake reached a good many miles; but I have neither leisure, nor inclination, to entertain you with uncertain reports of the extent and other circumstances; especially since a little further time and inquiry may enable me to give you a better warranted account.

Some OBSERVATIONS and DIRECTIONS about The BAROMETER.

First printed in the *Philosophical Transactions*, N^o xi. p. 181.
For April 2, 1666.

AS to the barometrical observations, (as for brevity's sake I use to call them) though you + guessed aright, that, when I saw those of the learned and inquisitive Dr. *Beale*, I had not mine by me, (for I left them some years since in the hands of a virtuoso, nor have I now the leisure to look after those papers) yet since, by the communication you have made publick, it is probable, that divers ingenious men will be invited to attempt the like observations, I shall (notwithstanding my present haste) mention to you some particulars, which, perhaps, will not appear unseasonable, that came into my mind upon the reading of what you have presented the curious.

WHEN I did, as you may remember, some years ago, publicly express and desire, that some inquisitive men would make baroscopical observations in several parts of *England* (if not in foreign countries || also) and, to assist them to do so, presented some of my friends with the necessary instruments: the declared reason of my desiring this correspondence was, (among other things) that, by comparing notes, the extent of the *atmospherical* changes, in point of *weight*, might be the better estimated. But not having hitherto received some account, that I hoped for, I shall now, without staying for them, intimate thus much to you: That it will be very convenient, that the observers take notice, not only of the day, but, as near as they can, of the hour, wherein the height of the mercurial cylinder is observed. For I have often found, that within less than the compass of one day, or, perhaps, half a day, the altitude of it has so considerably varied, as to make it, in many cases, difficult to conclude any thing certainly from observations, that agree but in the day.

+ See Num. ix. of the *Phil. Transact.* p. 159, the last paragraph.

|| Some whereof have been since invited by the Publisher, to give their concurrence herein.

It will be requisite also, that the observers give notice of the situation of the place, where their barometers stand, not only, because it will assist men to judge, whether the instruments were duly perfected, but principally, because that, though the baroscope be good, (nay, because it is so) the observations will much disagree, even when the atmosphere is in the same state, as to weight, if one of the instruments stand in a considerably higher part of the country, than the other.

To confirm both the foregoing admonitions, I must now inform you, that, having in these parts two lodgings, the one at *Oxford*, which, you know, stands in a bottom by the *Thames* side, and the other at a place four miles thence, seated upon a moderate hill; I found, by comparing two baroscopes, that I made, the one at *Oxford*, the other at *Stanton St. John's*, that, though the former be very good, and have been noted for such, during some years, and the latter was very carefully filled; yet by reason, that in the higher place, the incumbent part of the atmosphere must be lighter than in the lower, there is almost always between two and three eighths of an inch difference betwixt them. And having sometimes ordered my servants to take notice of the disparity, and divers times carefully observed it myself, when I passed to and fro between *Oxford* and *Stanton*, I generally found, that the *Oxford* barometer, and the other, did, as it were, by common consent, rise and fall together so, as that in the former the mercury was usually $\frac{3}{8}$ higher than in the latter.

WHICH observations may teach us, that the subterraneous steams, which ascend into the air, or the other causes of the varying weight of the atmosphere, do many times, and at least in some places uniformly enough affect the air to a greater height than, till I had made this trial, I durst conclude.

BUT, as most of the barometrical observations are subject to exception, so I found the formerly mentioned to be. For (to omit lesser variations) riding one evening from *Oxford* to *Stanton*, and having, before I took horse, looked on the baroscope in the former of these two places, I was somewhat surprised to find at my coming to the latter, that in places no farther distant, and notwithstanding the shortness of the time (which was but an hour and a half, if so much) the barometer at *Stanton* was short of its usual distance from the other, near a quarter of an inch, though, the weather being fair and calm, there appeared nothing of manifest change in the air, to which I could ascribe so great a variation; and though also, since that time, the mercury in the two instruments hath, for the most part, proceeded to rise and fall as before.

AND these being the only observations I have yet met with, wherein baroscopes, at some distance of place, and difference of height, have been compared (though I cannot now send you the reflexions, I have elsewhere made upon them) as the opportunity I had to make them myself, rendered them not unpleasant to me, so perhaps the novelty will keep them from being unwelcome to you. And I confess I have had some flying suspicions, that the odd phenomena of the baroscope, which have hitherto more posed than instructed us, may in time, if a competent number of correspondents do diligently prosecute the inquiries (especially with baroscopes, accommodated with Mr. *Hook's* ingenious additions) make men some luciferous discoveries, that possibly we do not yet dream of.

I KNOW not, whether it will be worth while to add, that since I was obliged to leave *London*, I have been put upon so many lesser removes, that I have not been able to make baroscopical observations with such a constancy as I have wished; but, as far as I remember, the quicksilver has been for the most part so high, as to invite me to take notice of it; and to desire you to do me the favour to inquire among your correspondents whether they have observed the same thing*. For, if they have, this

* This hath been inquired into, and is found, that several accurate and curious persons (as the most noble President of the Royal Society, the Lord Viscount *Brouncker*, Doctor *Beale*, Mr. *Hook*, &c.) have observed the same.

lasting (though not uninterrupted) altitude of the quicksilver happening, when the seasons of the year have been extraordinary dry (so much as to become a grievance, and to dry up, as one of the late Gazettes informs us, some springs near *Weymouth*, that used to run constantly) it may be worth inquiry, whether these obstinate droughts may not, by cleaving of the ground too deep, and making it also in some places more porous, and, as it were, spongy, give a more copious vent, than is usual to subterranean steams; which ascending into the air, increase the gravity of it. The inducements I have to propose this inquiry, I must not now stay to mention. But perhaps, if the observation holds, it may prove not useless in reference to some diseases.

PERHAPS it will be needless to put you in mind of directing those virtuosi, that may desire your instructions about baroscopes, to set down in their diaries not only the day of the month, and the hour of the day, when the mercury's height is taken, but (in a distinct column) the weather, especially the winds, both as to the quarters, whence they blow (though that be not always so easy nor necessary) and as to the violence or remissness wherewith they blow. For, though it be more difficult, than one would think, to settle any general rule about the rising and falling of the quicksilver; yet in these parts, one of those, that seem to hold ofttest, is †, that when the high winds blow, the mercury is the lower; and yet that itself does sometimes fail: for, this very day (*March 3.*) though on that hill, where I am, the somewhat westerly winds have been blustering enough, yet ever since morning the quicksilver has been rising, and is now risen near $\frac{3}{4}$ of an inch.

I HAD thoughts to add something about another kind of baroscope (but inferior to that in use) whereof I have given some intimation in one of the preliminaries to the *History of Cold*. But you have already too much of a letter, and my occasions, &c.

THE same noble observer further intimates, That, as for that cause of the height of the quicksilver in droughts, which by him is suspected to be the elevation of steams from the crust or superficial parts of the earth, which by little and little may add to the weight of the atmosphere, being not, as in other seasons, carried down from time to time by the falling rain, it agrees not ill with what he has had since occasion to observe. For, whereas about *March 12th*, at *Oxford*, the quicksilver was higher than, for aught he knew, had been yet observed in *England*, viz. above $\frac{1}{16}$ above thirty inches, upon the first considerable showers, that have interrupted our long drought, as he affirms, he foretold divers hours before, that the quicksilver would be very low, (a blustering wind concurring with the rain) so he found it at *Stanton* to fall $\frac{1}{4}$ beneath 29 inches ‡.

† See Num. ix, *Phil. Transact.* p. 157.—5, 8, 9. where the word generally signifies no more than for the most part.

‡ Dr. Beale concurs with this observation, when he saith, in a late letter of *March 19.* to his correspondent in *London*: By change of weather and wind, the mercury is sunk more than an inch, since I wrote to you on Monday last, *March 12.* This last night, by rain and south-wind, it is sunk half an inch.



Fig. 1.
p. 483.
505

Fig. 2.
p. 486.
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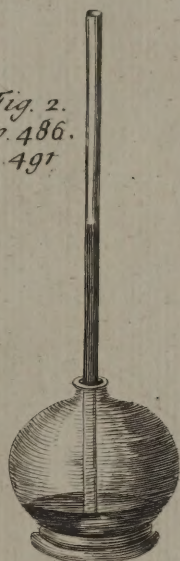


Fig. 5.

Fig. 3.
p. 486.
491

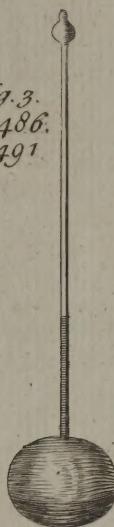


Fig. 6.
p. 505.

Fig. 4.
p. 487.

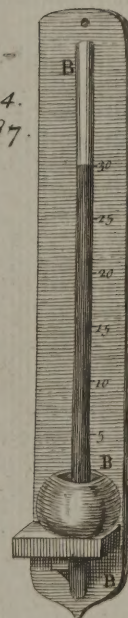


Fig. 5.
504.

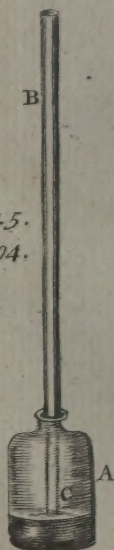


Figure 1

A. the Ball or Egg.
B C. the Stem
D. the little Aqueous
Cylinder.

Fig. 2. the open Weather
Glass

Fig. 3. the sealed Weather
Glass or Thermoscope

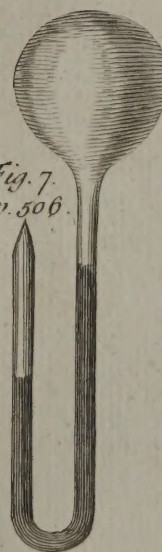
Fig. 4. the Barometer
or Mercurial Standard
placed in a Frame BB.

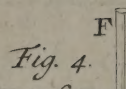
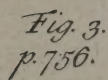
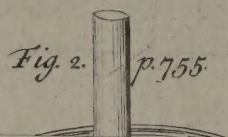
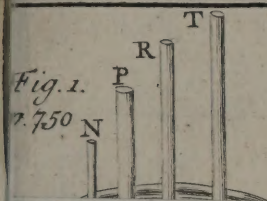
A. the Vial
B C. the Pipe cemented
into the neck of the Vial
open at C. & sealed at B.

Fig. 6.

A. the Bolt head
B. the Small Stem
B C. the Cylinder of
Water inclos'd

Fig. 7.
p. 506.







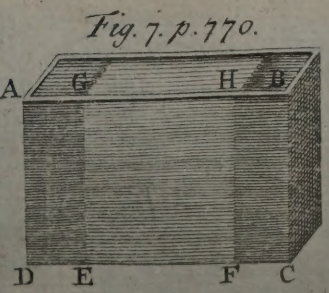
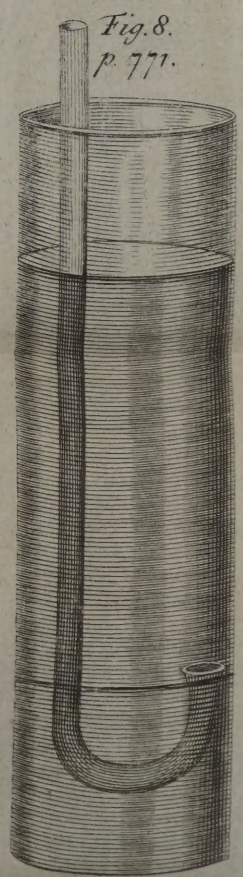
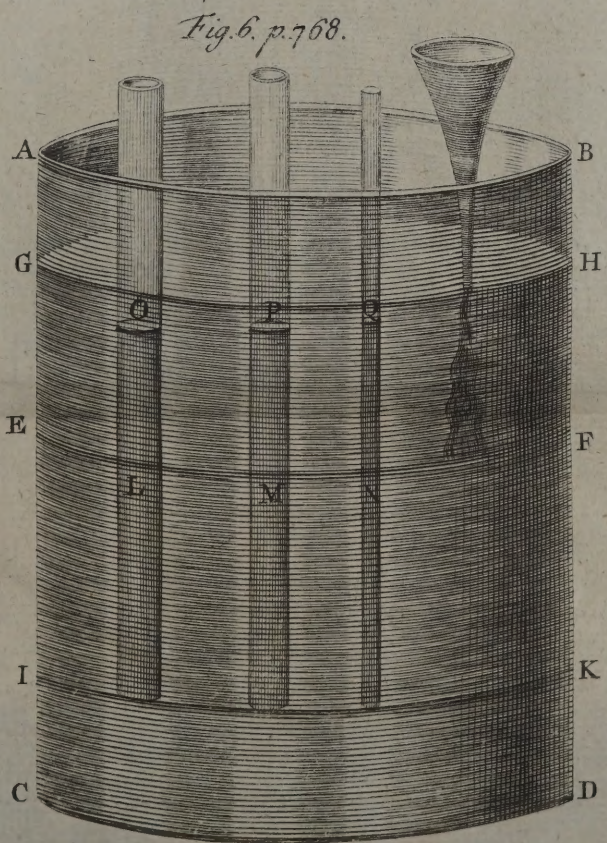
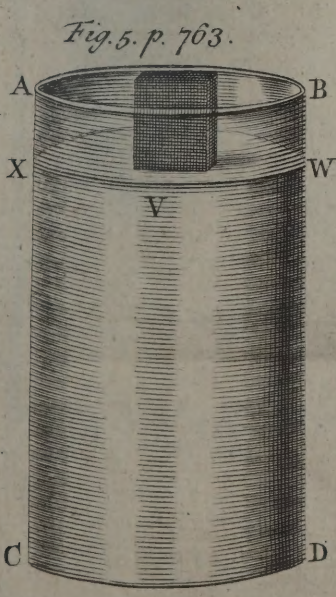
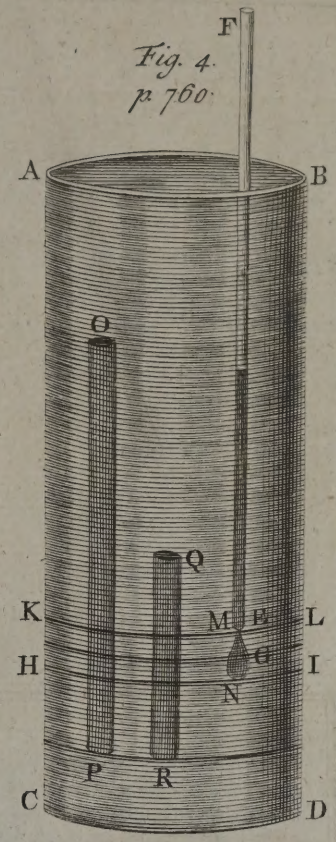
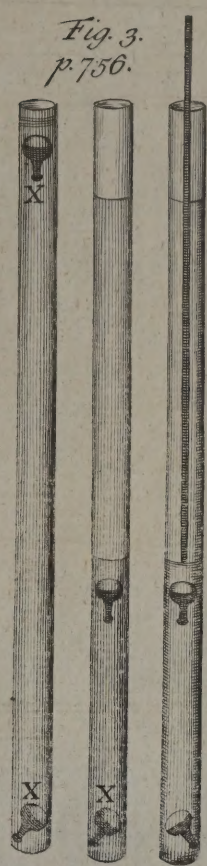
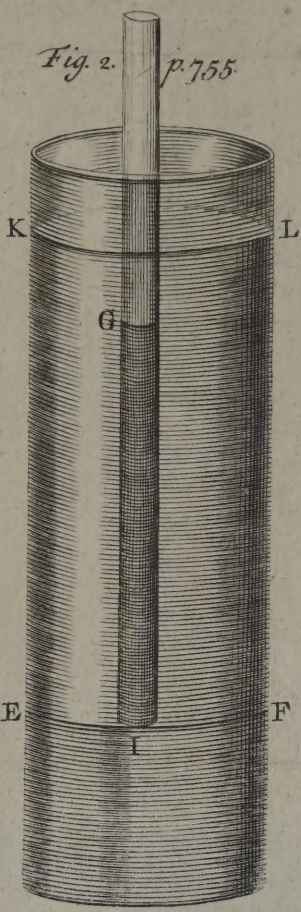
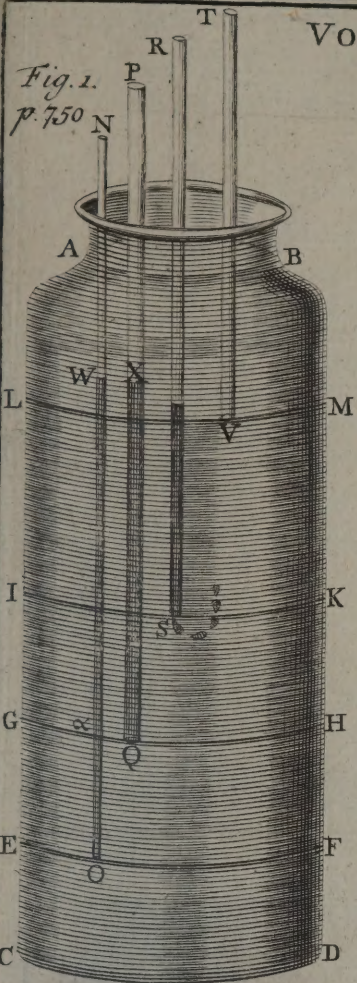


Fig. 12. p. 774.

Fig. 10. p. 772.

Fig. 9. p. 772.

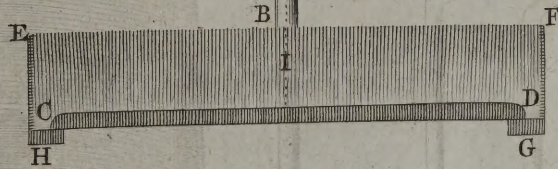
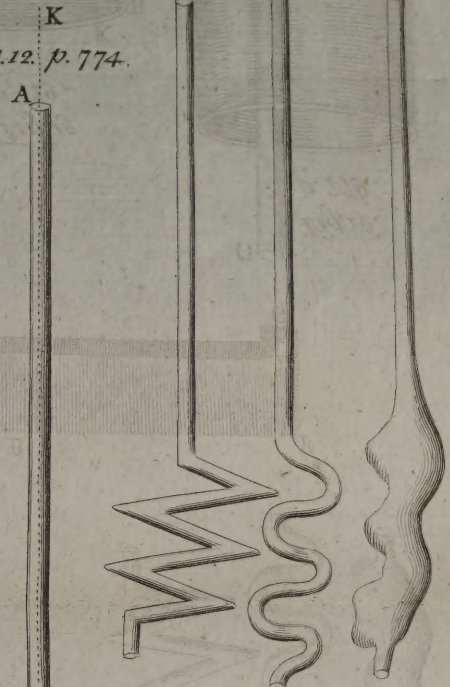
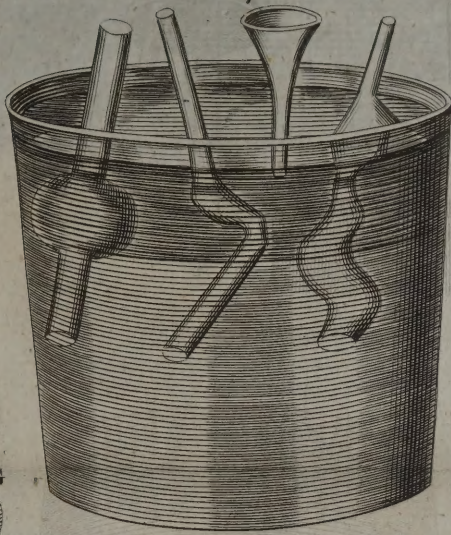
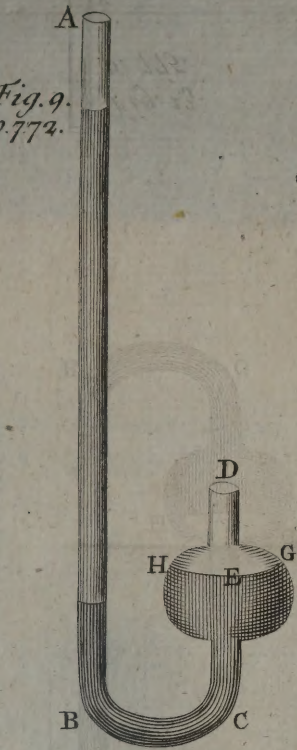


Fig. 14. p. 777.

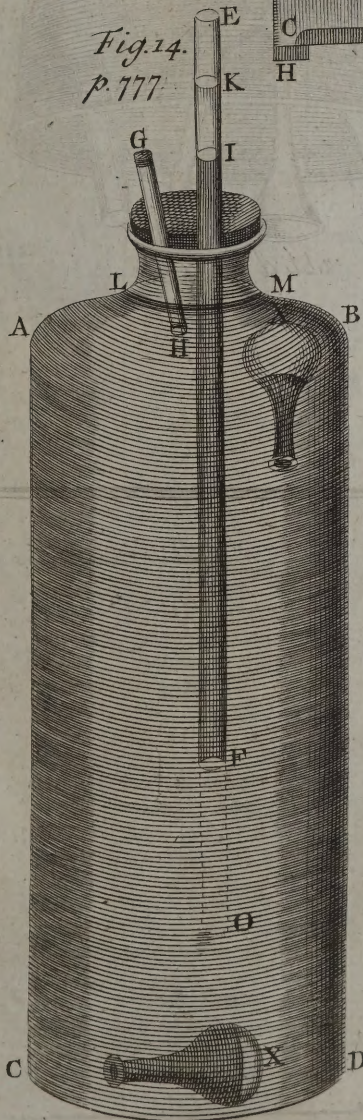


Fig. 15. p. 779.

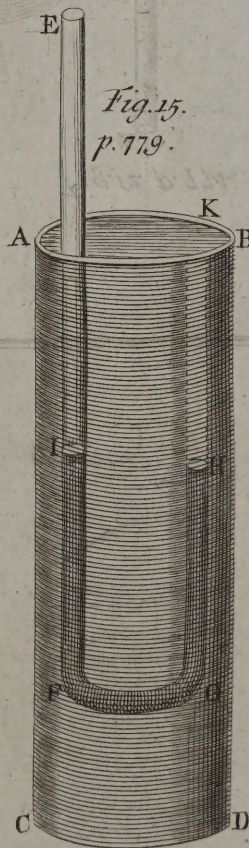


Fig. 16. p. 779.

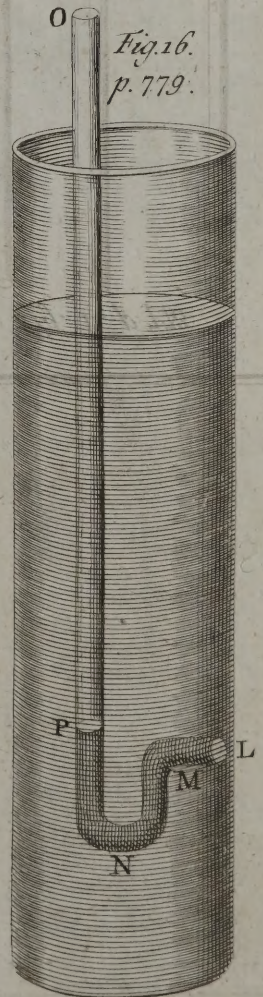


Fig. 17. p. 780.

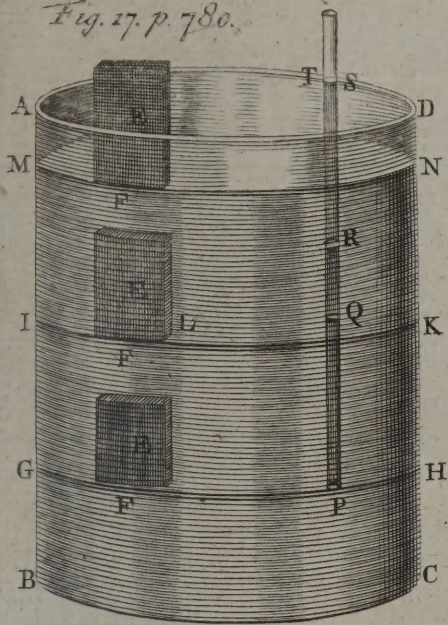


Fig. 18. p. 781.

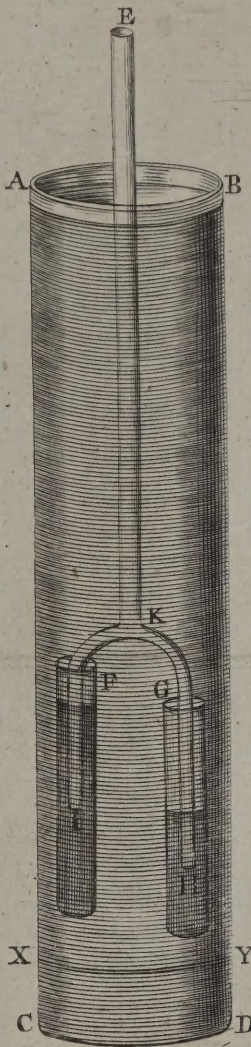


Fig. 19. p. 784.

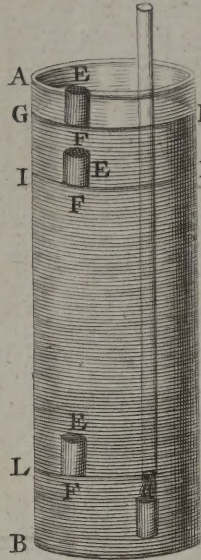


Fig. 20. p. 785.

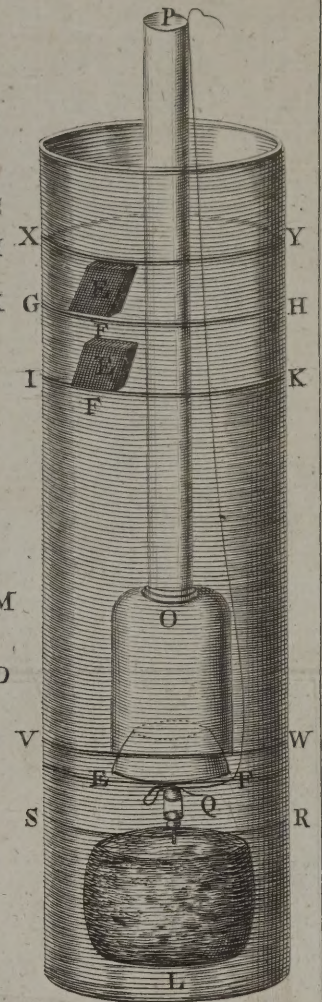


Fig. 21. p. 788.

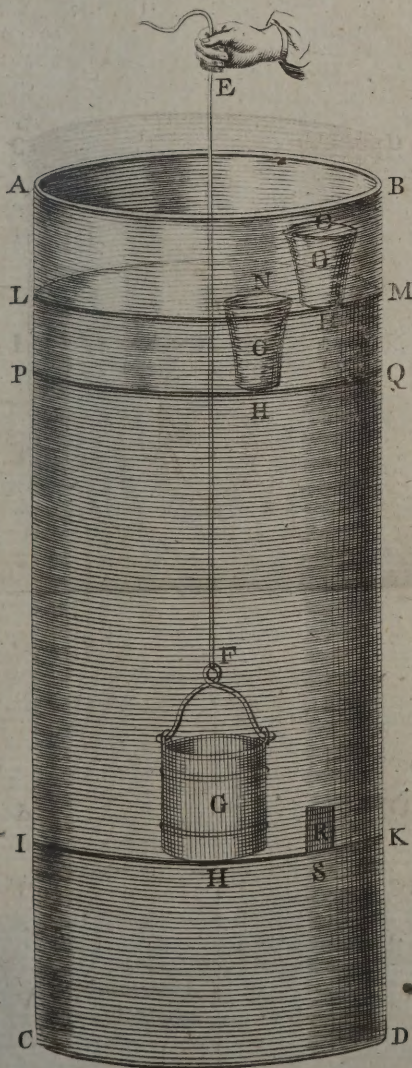


Fig. 22. p. 793.

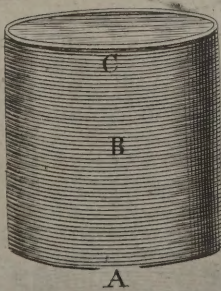


Fig. 23. p. 795.

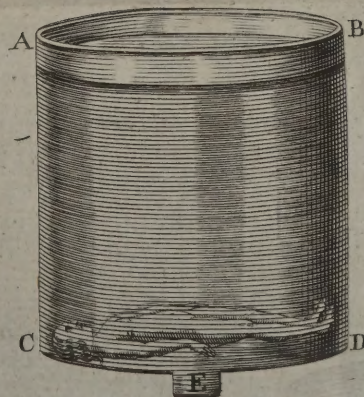


Fig. 24. p. 796.

